

Curriculum Unit on Risk Literacy Using Case Study and Probability to  
Teach Risk to Post-Secondary Students in Non-STEM Programs

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## **Abstract**

This study was designed as a resource to develop risk literacy for students enrolled in non-STEM programs at the post-secondary level using case studies, context analysis, basic mathematics, geometry and statistics. Risks are an outcome of human activity that impact individuals personally, professionally, politically and globally. Numerous issues influence risk literacy education such as adult literacy and numeracy, mathematics curriculum, socio-political and equity issues in mathematics education, teacher education and access to education. The study consists of eleven lessons in varied contexts. Review of the curriculum unit was conducted and confirmed that risk literacy education requires contextual material, deconstruction of language used to express probability, greater attention to language use, and visual representation of data to facilitate comprehension. Review of the unit also revealed that risk literacy can be achieved by learners from different occupational backgrounds who do not have detailed prior working knowledge of risk. Reviewer feedback was used to guide unit development. Participants were provided with lessons for evaluation and agreed that risk literacy was a relevant and practical skill.

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## Table of Contents

|   |        |
|---|--------|
| Abstract .....  | ii     |
| Acknowledgements .....  | iii    |
| List of Tables .....  | iv     |
| List of Figures .....   | v      |
| <br>CHAPTER ONE: INTRODUCTION TO THE STUDY .....                          | <br>1  |
| Background of the Problem .....   | 2      |
| Statement of the Problem Context .....                                    | 6      |
| Purpose of the Study .....  | 7      |
| Objectives .....  | 8      |
| Rationale .....   | 8      |
| Scope and Limitations of the Study .....                                  | 10     |
| Outline of Remainder of the Document .....                                | 12     |
| <br>CHAPTER TWO: REVIEW OF THE LITERATURE .....                           | <br>14 |
| The Need to Understand Risk .....   | 16     |
| Defining Risk .....   | 20     |
| Adult and Higher Education .....  | 21     |
| Adult Literacy: Present and Future .....                                  | 25     |
| Connection Between Literacy and Mathematics .....                         | 29     |
| Innumeracy and Contributing Factors .....                                 | 35     |
| Mathematics as a Social Filter and Equity .....                           | 39     |
| Adult Mathematics Education .....   | 45     |
| Chapter Summary .....   | 49     |
| <br>CHAPTER THREE: METHODOLOGY AND PROCEDURES .....                       | <br>52 |
| The Culture of Risk Taking .....  | 52     |
| The Development Process .....   | 54     |
| Evaluation of Curriculum Unit .....                                       | 60     |
| Limitations of the Project .....  | 60     |
| Expected Findings .....   | 61     |
| <br>CHAPTER FOUR: CURRICULUM UNIT .....                                   | <br>62 |
| Unit Plan Overview .....  | 62     |
| Risk Literacy: Using Critical Thinking, Case Studies and Probability..... | 66     |
| Lesson #1: Exploring Context .....  | 67     |
| Lesson #2: Math Anxiety and Numeracy .....                                | 69     |
| Lesson #3: Exploring the Relationship Between Language and Math .....     | 70     |
| Lesson #4: Context Analysis .....   | 71     |
| Lesson #5: Numeracy and Mathematical Thinking .....                       | 73     |
| Lesson #6: Risk Communication .....                                       | 74     |
| Lesson # 7: Evaluating Risk (Part I) .....                                | 75     |
| Lesson # 8: Evaluating Risk (Part II) .....                               | 76     |

|   |     |
|---|-----|
| Lesson # 9: Critical Thinking, Decision-Making and Heuristics ..... | 77  |
| Lesson # 10: Case Study – Self-Study .....                          | 78  |
| Lesson #11: Project 2 – Alternate Self-Study .....                  | 79  |
| CHAPTER FIVE: SUMMARY OF THE PROJECT .....                          | 80  |
| Evaluation of Lesson .....  | 80  |
| Implications for Practice .....                                     | 81  |
| Recommendations for Future Research .....                           | 82  |
| Conclusion .....  | 83  |
| References .....  | 85  |
| Appendix A: Definitions and Terminology .....                       | 104 |
| Appendix B: Lesson Materials and Evaluations .....                  | 107 |
| Appendix C: Reviewer Questionnaire .....                            | 127 |

## List of Tables

| Table   | Page |
|---|------|
| 1. Risk and Probability Content by Course Outline ..... | 17   |

## List of Figures

| Figure                                | Page |
|---------------------------------------|------|
| 1. Proposed Risk Literacy Model ..... | 128  |

## **CHAPTER ONE: INTRODUCTION TO THE STUDY**

On a daily basis, people are required to make decisions about their health, society and livelihood with increasing responsibility; in essence taking on greater risk. Barlow (1998) remarks that, risk management is the outward expression of an innate drive in living beings, microorganisms, corporations, governments and groups to respond to risks, which involves the perception and appraisal of risk, with measures that minimize their cost and maintain a constant environment (p.88).

In a democratic society, citizens are called on to become active participants in social and geo-political issues that involve risk often assessing issues and basing decisions on emotional responses. Finucane (2013) comments that the reliance on feelings to evaluate risk is referred to as the ‘affect heuristic’. The affect heuristic develops as fear, dread, anger, hope or relief are experienced after the risk-benefit calculation is completed (p.58). These affective reactions are part of the experiential system referred to as System I of the dual-process theory, proposed by Kahneman (2013) in decision theory.

This study examines the cognitive process of decision making, the impact of low numeracy and literacy on decision making, and the types of reasoning involved in risk comprehension. The study explores how adult literacy and numeracy, foundational to mathematical reasoning and comprehension, is impacted by mathematics curriculum, the community and educational policy. In addition, this study seeks to develop an understanding of the instrumentalization of mathematics to create equity issues inside and outside the classroom moreover, how this inequity is socially reproduced and the potential influence on risk literacy education.



The unit is a proposed method to teach risk comprehension and is designed as a resource for instructors teaching at the post-secondary level. This unit consists of case studies adapted from government, media and industry publications in electronic and print formats. The goal of this unit is to develop and increase the learner's ability to identify, comprehend, analyze, illustrate and communicate risk in a variety of contexts.

### **Background of the Problem**

Canada, like many developed countries, looks to its entrepreneurs to lead business and innovation. In researching the literacy level of Canadian entrepreneurs, the Toronto Star published an article in January 2015 which reveals that Canadian small business owners "sorely lack the basic financial knowledge" (Wright, 2015) to manage their companies. Of the 683 Canadian small business owners surveyed, 39% failed the financial literacy quiz and 57% of the participants achieved a quiz score of 50% or less. When interviewed, 47% of Canadian entrepreneurs believe that basic financial training would help their business be more profitable (Wright, 2015). Kahneman (2013) makes the following observation about entrepreneurs:

A common thread of boldness and optimism links businesspeople, from motel owners to superstar CEOs. The optimistic risk taking of entrepreneurs surely contributes to the economic dynamism of a capitalistic society, even if most risk takers end up disappointed. It is tempting to explain entrepreneurial optimism by wishful thinking, but emotion is only part of the story. Cognitive biases play an important role. (p. 259)

In addition to poor financial literacy and cognitive bias, Canadian entrepreneurs and executives have been observed to demonstrate a lack of statistical literacy. For example,

Wagner (2014) comments that the Canadian Council of Chief Executives (CCCE) over-reacted to the Canadian mathematics results for PISA published in a national Canadian newspaper in 2013. The CCCE called for a “return to traditional forms of teaching math” (Wager, 2014, p. 5), when in fact Canada showed no significant difference between the 2009 and 2012 PISA results. Wagner (2014) remarks that based on the 2012 PISA results Canada performs well internationally but as a country, Canadians do not understand and are poorly equipped to read statistics. Wagner (2014) adds that Canadian citizens are not equipped to think critically about expert reports on statistics and this applies to business leaders as revealed by their poor mathematics and paranoid response.

Similar examples, documented by Gal (2002), Gigerenzer (2002, 2014), Kahneman (2013), Paulos (2001), demonstrate how statistical illiteracy can be used to panic the public in order to further the agenda of a group(s) in order to influence public policy and this is the warning that Wagner (2014) brings to the publics’ attention. In addition, it also underscores and verifies that statistical innumeracy is real, it exists at several levels within the society, it can be used to exploit or influence public opinion and political decision making, and to influencing mathematics curriculum content, by asserting the incorrect notion that back-to-basics mathematics, increased testing and drills are the appropriate course of action, when in fact it does not address the issue of statistical illiteracy and innumeracy at all. Furthermore, this article also reflects the need for critical thinking and critical literacy required to identify and unearth meta narratives, identified by Giroux (1980), in order to understand the impact of communication control and reveal the underlying cultural hegemony. The reaction to the 2012 PISA scores exemplifies the need for the continued development of adult literacy, statistical literacy

and numeracy and to address the issue of what directs/informs the development of mathematics curriculum.

Multiple surveys over the last two decades show no significant improvement in numeracy among Canadian adults. The most recent survey information from Program for International Assessment of Adult Competencies 2013 (PIAAC) states that Canada is among “the group of countries with a significant portion of the adult population (ages 16-65) at or below Level 1 on numeracy scales” (OECD, 2013, p. 35). The International Adult Literacy and Skills Survey (IALSS) 2005, reported by ABC Canada Literacy Foundation, that assesses literacy, numeracy and problem-solving skills also reported that “forty-eight per cent of Canadian adults, age 16 and over, approximately 12 million Canadians, have low literacy with 20 per cent scoring Level 1, the lowest proficiency, in prose literacy, and 28 per cent at Level 2” (p. 1). OECD in *Skills Outlook* (2013), reports that ‘Canada ranks below the OECD average in numeracy furthermore, the proportion of Canadians at the lower level is greater than the OECD average’ (p. 35). According to IALSS (2005), these statistics reflect no significant difference from 1994, when 22% scored Level 1 and 26% scored Level 2. Among the findings, IALSS (2005) reports that currently, a significant proportion of the adult Canadian population currently do not possess the numeracy and literacy skills needed by the Canadian economy. Although Canadian youth are highly skilled on average, too many fail to achieve level 3 literacy to occupy most jobs. Furthermore there are provincial and territorial fluctuation in literacy levels which will impact the provincial skill profile and economic productivity. Both PIAAC (2013) and IALSS (2005) identify three areas impacted by adult innumeracy. Firstly, the socio-economic impact on decision making, participation

(employability), and competitiveness of the Canadian economy is diminished, and in some cases paralyzed, due to low levels of innumeracy. Secondly, the lack of any significant change in adult numeracy over the last two decades highlights the need to re-examine adult literacy and numeracy curriculum. Lastly, recent Canadian graduates with post-secondary education may still not have the literacy and numeracy skills required for future jobs created by the Canadian economy due to low and declining literacy levels.

Upon review of the current Ontario mathematics curriculum for post-secondary institutions, Dion (2014) argues that Canada, as an OECD country, has to shift its view of numeracy as a discrete part of the curriculum, which is ‘discipline-based’, to an essential skill. Dion (2014) raises the issue that discussion and development of numeracy skills cannot be restricted solely to numeracy skills for STEM (Science, technology, engineering and mathematics) subjects. Dion (2014) argues that, if numeracy is to be regarded as an essential skill, for everyone regardless of the program of study or employment, then postsecondary institutions need to examine how they will build numeracy skills for those student who have chosen arts, social science, language or philosophy programs.

Recent publications thus provide a brief glimpse into the discussion and areas of declining adult numeracy found among entrepreneurs, business leaders, and citizens. Over the last twenty years, PIAAC (2013) and IALSS (2005) report no change in adult numeracy, and this impacts employability and the Canadian economy. In addition, there is a call to re-examine adult numeracy as an essential skill, as discussed by the OECD, rather than a single focus on discipline based mathematics focused on science, technology, engineering and mathematics (Dion, 2014) and the need to address gender

differences in full-time employment that under-utilize skills. The curriculum unit presented in this study takes a pragmatic approach to numeracy, using examples from daily life to expand adult statistical and risk literacy using case studies to develop comprehension of probability, risk, and problem solving skills in a given context.

### **Statement of the Problem Context**

Over the last 20 years, adult numeracy in Canada has remains below acceptable levels. Innumeracy occurs within several segments of the Canadian population, as well as among recent post-secondary graduates and professionals. OECD (2013) reports that Canadian adult numeracy continues to fall below the OECD average. More notably, that development and maintenance of numeracy and literacy skills primarily occurs outside formal education and that if these skills are to be retained there must be opportunities for continued life-long learning for both high and low-skill occupations, especially in the technology sectors. Also recorded in the report is the under-use of qualified and skilled individuals due to field-of-study mismatch, “whereby individuals work in an area this is unrelated to their field of study and their qualifications are not fully valued” (OECD, 2013, p. 39). In addition, OECD (2013) reports that although women and men may have equal qualifications it does not translate into equal opportunities. The report finds that women and men have similar proficiency levels but the difference in skill use between men and women may be the result of gender discrimination and the fact that a larger proportion of women are more likely to be employed in part-time work rather than full-time jobs, which presumably requires less intensive skill use. OECD (2013) reports that the survey result confirm gender differences in the use of literacy and numeracy skills due to the fact that men appear

slightly more proficient but that they are more commonly employed in full-time jobs where their skills are used more intensively (p. 40-41).

The International Adult Literacy and Skills Survey (IALSS) 2005 reports that “large percentages of adults do not currently possess the literacy and numeracy skills needed to fill the types of jobs that the Canadian economy is creating is problematic and while Canada’s youth are highly skilled on average, too many fail to reach Level 3, the level needed to meet the requirements of most jobs being created by the Canadian economy” (IALSS, 2005, p. 4). In addition, Dion’s (2014) review of mathematics curriculum at both Ontario Colleges and Universities reports that colleges and universities do not make provision for mathematics (numeracy) education of post-secondary students in non-STEM programs, deemed an essential skill by OECD countries (Dion, 2014, p. 19). This curriculum unit is a step toward addressing adult innumeracy and is designed as a resource for educators to develop students’ cognitive, statistical and risk literacy skills at the post-secondary level for non-STEM programs.

### **Purpose of the Study**

The purpose of this curriculum unit is to provide post-secondary educators with a resource to develop basic cognitive, statistical and risk literacy skills. In addition to developing statistical and risk literacy, this curriculum is developed to engage problem solving, dialogue, use critical thinking skills, visual story-telling and context analysis using diagrams, concept maps, slideshows, spreadsheets and other graphic tools. This curriculum unit assumes that students have minimal or no statistical knowledge, and the goal is to use the resource to ‘unpack’ the information they see in each case and to evaluate the claims made to decide on a course of action, if required.

## **Objectives**

The objectives of this curriculum unit are threefold. First, to provide a resource for instructors at the post-secondary level to use to examine different forms of risk with social science students. Secondly, to engage and develop risk literacy in students to foster numeracy, critical thinking and decision making. Lastly, to provide a flexible resource for both the student and instructor to explore and expand knowledge; to utilize student and teacher creativity, and for the continued development of adult numeracy.

## **Rationale**

According to OECD (2013), approximately 12 million Canadians out of 33.5 million have a literacy level no higher than Level 2, which can have a significant impact on Canada's future economy, along with their decisions pertaining to health and finance. The PIAAC (2013), IALSS (2005), OECD (2013) and Dion (HEQCO, 2014), raise several issues pertaining to adult numeracy, namely that (a) over the last 20 years there has not been significant improve adult literacy and numeracy in Canada; (b) regions within Canada will not have enough post-secondary graduates with sufficient literacy skills to fill the jobs created by the Canadian economy; (c) gender discrimination and skills use mismatch are contributing factors to declining and available skilled labour; and (d) currently, there are no existing numeracy program for non-STEM students at the postsecondary level designed to address the issue of innumeracy or risk illiteracy.

The other more challenging reality is living within the risk culture of a developed country. Klein (2010) in "Addicted to Risk", has documented and examined the behavior and historical nature of *risk culture* in the United States and other developed

nations – namely, examining the perpetuation and investment into *risk culture* and the impacts on the environment and society. While there may be benefits, North American education systems reflect the dominant culture (Brookfield, 2005; Freire, 2001; Giroux, 2016; Nesbit, 2002) and throughout developed/industrialized nations education has been, and continues to be, the incubator and source of raw material that fuels industrialization (Robinson, 2010).

As developed nations move into the 21<sup>st</sup> century, the United States [and Canada] have entered into an era of “unknown unknowns – the unfathomable complexity of our modern, human-made world” (Dixon, 2001, p. 172) and what Giroux (1980) refers to as the “rise of the new illiteracy” (p. 92) by mass culture. Giroux (1980) comments that, “the capacity to think critically or even to engage in meaningful social discourse has been seriously eroded by the massified culture industry” (p. 92). The ‘new illiteracy’ has not only caused damage to critical thinking of citizens, but has also done significant damage to the “substance of democracy itself” (Giroux, 1980, p. 92). Gigerenzer (2002) adds that is no full acknowledgement of the challenges to literacy in democratic societies of the twenty-first century. He states, “the ability to read and write, is the lifeblood of an informed citizenship in a democracy” (p. 2). Gigerenzer (2002) further adds,

*Risk literacy* is the basic knowledge required to deal with a modern technological society. Without it, you jeopardize your health and money, or may be manipulated into unrealistic fears and hopes. One might think that the basics of risk literacy are already being taught. Yet you will look in vain for it in most high schools, law and medical schools and beyond. As a result, most of us are risk illiterate (p. 2)



Both Giroux (2016) and Gigerenzer (2002) view literacy as an educational imperative for citizens of 21<sup>st</sup> century democracies. Like literacy, Gigerenzer (2002) views risk literacy as an educational imperative or essential skill for technologically driven societies, but a skill which is not explicitly taught.

This unit is designed to teach risk literacy to non-STEM adult students at the post-secondary level to develop numeracy and problem-solving skills, foster learner self-direction and engage critical thinking. It is a flexible resource that can be easily expanded or modified based on the subject area, with the ability to directly input additional material, context and data. In addition, this unit serves as a basis for the development of supplemental units that can be further modified to an advanced level and imported into an MS Access database for more advanced risk instruction.

This unit would be of interest to instructors and administrators because it serves as a prototype for other potential numeracy modules that can be used to teach risk to students in social sciences, humanities, business or skilled trades. More importantly, it is a step toward providing non-STEM students with relevant numeracy education. Secondly, this unit serves to move risk literacy (numeracy) into an essential (daily) skill and lastly, this unit can be used to provide measurable results in adult numeracy.

### **Scope and Limitations of the Study**

This curriculum unit is designed to achieve a broad comprehension of risk within given contexts which involves problem solving, calculating risk, charting and interpreting results within context. More precisely, this project is designed to address the lack of resources in the current post-secondary curriculum to provide instruction on

risk. Each lesson is meant to be presented, discussed in class, practiced individually or in a group, reviewed and summarized. Unit evaluation is in the form of a summative project, identical in structure to the curriculum unit, or electronic portfolio. Evaluation of the effectiveness of this curriculum unit and additional revisions are also future considerations.

Instructors at the post-secondary level need to be familiar and comfortable with the use of technology in the classroom such as podium projectors, spreadsheet and presentation software applications, and to conduct internet search for relevant data. The unit involves case analysis and context analysis to facilitate class discussion and to model the inputting and analysis of data in the spreadsheet. The unit requires that students have access to computers and the appropriate software applications to make use of the spreadsheet, in addition to having previous software experience above the beginner level. Otherwise, materials can reformatted or modified to be used in hard copy formats.

The curriculum unit is limited to cases that are commonly reported events, including weather events, medical reports, spread of infectious diseases, investing, etc. For Instructors who are looking for cases pertaining to their specific subject area, they will need to supplement this unit with additional cases for their specific courses.

Instructors should also be mindful of the pace of instruction; for instance, it may appear that the lesson moves too slowly. Instructors need to make sure that students are given the time they need to digest and process the case information. Students are expected to identify details, describe context and explore the pros and cons of the case they are to analyze – this takes time. Not every student will learn from this

instructional style, so it is recommended that Instructors move gradually through the unit from the initial Instructor-led lesson to lessons that are student-led, including presentation of case or group findings, or facilitating a discussion.

In addition, Instructors must be cognizant of the cultural and age diversity of the classroom. Although attention has been paid to creating cases that are generic in nature, some cases provided may not be suitable for all classes for instance. For example, students could be asked to determine the probability of side-effect from an anti-inflammatory arthritic medication prescribed to patients over 75 years of age. In cases where students are unfamiliar with the drug classification or its use or age related issues, I suggest the substitution of a more appropriate case and then return to this case at a later date – referred to as *scaffolding* in the adult education literature (Novak, 2010, p.80-81).

Lastly, instructors should be cognizant that adult students come into the classroom with personal experiences, expectations and attitudes towards their learning. Instructors will not be privy to the motivations of their students and more often than not, they are not privy to the ‘good and bad’ previous experiences students have had with mathematics and the material they are about to teach. Instructors need to be prepared to manage objections and potential disagreements that may arise from the discussion of a case and to help the student move forward.

### **Outline of Remainder of the Document**

Chapter One discussed declining adult numeracy and the need for a generic curriculum unit that teaches risk to post-secondary adult students in non-STEM programs. Chapter Two describes the current issues in adult education and the changes

that are needed in educating adults in statistics and risk. Chapter Three outlines the development of the curriculum unit from its inception to its final product. Chapter Four includes the entire curriculum unit, which consists of the unit plan, lesson plans, evaluation rubrics, electronic articles, links, activities and graphic organizers for analysis. Chapter Five then summarizes the curriculum unit and suggested recommendations for theory, practice, and further research.

## CHAPTER 2: LITERATURE REVIEW

This project is about risk literacy. Why choose risk? This journey began with a need to understand and make meaningful sense of the statistics generated in graduate research and to interpret risk. It also surfaced in my practice as a business instructor, when conversing with students about business risk and the importance of addressing this in a business proposal for decision-making purposes. I soon came to recognize that I was ill-equipped to do either, and this is where the journey began.

As undergraduate and graduate students conducting academic research and in teaching practice, calculation and discussion of probabilities appears to be the norm. Yet, there is an observed and palpable struggle to interpret and comprehend the meaning of the value on its own. I have come to understand that calculated values – specifically probabilities, in and of themselves, offer little insight if we cannot locate this value in a context to provide meaning. When the probabilities are placed in context it opens the door to and engages students in discussion and awakens them to re-examine the assumptions they make. Nevertheless, calculating probabilities or statistics is not sufficient enough to understand risk (Gigerenzer, 2014; Ropeik, 2010).

Is it necessary to understand risk? There are several examples, a current one is on the front cover of *Consumer Reports* magazine in May 2016, the heading reads, “What You Don’t Know About Your Doctor Could Hurt You” – How to Make a Safe Choice (in much smaller print) (Rabkin-Peachman, 2016). The article is an overview of State Medical Boards and the medical practitioners on disciplinary probation, who have been allowed to continue to practice on patients in the state of California. Some practitioners are on probation for substance abuse and addiction, sexual misconduct, clinical

misdiagnoses or performing unwanted and incorrect surgeries, or are under investigation for illegally selling prescription medication. In most of these cases, the public is totally unaware. In one case, Rabkin-Peachman (2016) describes the case of a pediatrician who had been cited 13 times because she was under the “influence of drugs to such an extent that she was impaired from her ability to practice medicine” (p. 33). How is the public protected and how does the public become informed in such situations? Canadians are not immune to this issue either, which begs the question of whether the Canadian public is protected. Gigerenzer (2002) comments that, “estimates indicate that every year more than 300,000 American women who do not have breast cancer undergo a biopsy” (Gigerenzer, 2002, p. 65). According to Gigerenzer (2002, 2014) the public is subjected to numerous tests that have high false-positive rates such as DNA, HIV, mammograms and fingerprint tests, resulting in tremendous physical and psychological harm and financial strain.

In another example, Rosenthal (2005) comments that the SARS crisis in Toronto, 2003 never reached the epidemic proportions that were reported in the media. In fact, “the SARS crisis resulted in less than fifty fatalities” (p.80) whereas thousands of Canadians die each year from influenza (p. 80). Both Rosenthal (2005) and Ropeik (2010) comment that the reported SARS crisis is a good example of over-estimating the probability of a highly improbable event. It also demonstrates how different interpretations of probability can produce drastically different estimates of risk (Gigerenzer, 2002, p. 28).

### **The Need to Understand Risk**

From my perspective as a parent, post-secondary instructor and graduate student, understanding risk is relevant because risk is part of daily life. Risk is a product of human activity, that is easily miscommunicated, and is communicated to different audiences for different purposes with potentially profound and irreversible impacts.

Creating a curriculum unit on risk encompasses three main areas of inquiry. First, thus far, risk is not part of the elementary, secondary, or post-secondary curriculum – with the exception of professional courses in insurance (actuarial), law, engineering, science and medicine. Leading to the next question, how many parents can and know how to explain and educate their children, teens or young adults about risk? Secondly, how do teachers (in non-STEM fields) instruct and help their students understand and analyze risk? Thirdly, what resource can instructors and the ordinary person use to evaluate and make decisions that involve risk? Answers to these questions and to locate risk instruction were sought by reviewing currently published curriculum documents such as: Program Standards for Business for the Accounting and Business Administration-Finance programs (MTCU, 2009), the Ontario Adult Literacy Curriculum Framework (OALF) (MTCU, 2011), the Revised Ontario Mathematics Curriculum for Grades 11 and 12 (Ontario Ministry of Education, 2007), and course outlines for Business Statistics 1 and 2, Mathematics of Finance, Quantitative Approaches to Decision Making, and Risk Management and Estate Planning taught at a local community college. A brief summary of risk instruction found in course outlines is summarized in Table 1.

Table 1

*Risk and Probability Content for Business Diploma and Degree Programs, by Course Outline*

| Course Outline                             | Probability (Y/N) | Risk (Y/N) |
|--|-------------------|------------|
| Mathematics of Finance (introductory)      | N                 | N          |
| Business Statistics (1)                    | Y                 | N          |
| Business Statistics (2)                    | Y                 | N          |
| Quantitative Approaches to Decision Making | N                 | N          |
| Risk Management & Estate Planning          | N                 | Y          |

*Note.* Mathematics of Finance is an introductory core prerequisite course for five diploma programs: Business Administration, Accounting & Finance – Financial Planning Specialization, Finance & Accounting, Accounting & Payroll, and International Business. Summarized from course outlines Faculty of Business and Faculty of Continuing Education, Seneca College, 2013.

<sup>a</sup> Business Statistics 1 taken by students enrolled in Finance & Accounting or International Business diploma programs. <sup>b</sup> Business Statistics 2, 4<sup>th</sup> year subject, taken by student enrolled in International Accounting and Finance degree program. <sup>c</sup> Risk Management taken in final semester by students enrolled in Accounting & Finance (Adv.) diploma, Financial Planning Specialization or Financial Planning Certificate. Risk is part of the Actuarial Science program taught in Canadian universities.



Table 1 summarizes only the business course outlines that list probability and risk as an instructional topic, and are foundational to five college diploma programs and the International Accounting and Finance degree program. Out of the five outlines, four are mathematics-based courses (Mathematics of Finance, Business Statistics 1 and 2, Quantitative Approaches to Decision-Making). Out of those four, two specifically list probability. None of the math courses list risk as a topic in the course outline. Although risk may not be listed in these outlines, instructors and professor have the option to include materials on risk if it is relevant to the listed outline topics.

Further review of Table 1 reveals where some of the gaps in risk comprehension could result. For instance, College students completing the Accounting and Finance (Advanced) diploma, Financial Planning specialization or Financial Planning certificate are required to complete the risk management and estate planning course in the last semester of the program. This raises the following questions: Is one semester a sufficient amount of time to develop an adequate depth of knowledge or comprehension of risk? Will a diploma in Financial Planning provide the sufficient risk knowledge to advise the public on estate and financial planning?

For example, Stigler (1983) discusses economic literacy, and provides added insight into why we need to “learn/do it for ourselves” (p. 63) and not rely on expert knowledge to be economically literate. He states,

Experts do not fully meet the citizen’s need for economic knowledge for two reasons:

1. Often economic issues involve the nature of fundamental social goals rather than technical economic knowledge. Most experts operate more at the level of technique.
2. The expert advice on economic issues which does come forth in ample quantity is often partisan. (Stigler, 1983, p. 63)

According to Stigler (1983), there are two reason for citizens to become economically literate:

1. As a means of communication among people, using a basic vocabulary or logic that is frequently encountered that the knowledge should be possessed by everyone.
2. As a type of knowledge frequently needed and yet not susceptible to economical purchase from experts. (p. 61)

The same reasons identified by Stigler (1983) are equally valid and apply to risk and statistics as well. For instance, the average citizen does, in fact, need to have a basic understanding of the vocabulary and common knowledge of risk. Secondly, a consistent means of risk communication to the public using the same common risk knowledge that is clearly communicated needs to be articulated. Lastly, this knowledge needs to be accessible and freely available (Gal, 2002; Gigerenzer, 2002, 2014; Gigerenzer & Edwards, 2003; Ottaviani, 2002; Ropeik, 2010; Spiegelhalter, 2008, 2012). According to Paulos (2001),

Without some appreciation of common large numbers, it's impossible to react with the proper sobriety to a warhead carrying a megaton of explosive power (p. 9).

My hope is that this project is a first step toward providing a resource for instructors and teachers to teach risk in their classrooms that is flexible, engages students to think critically and to develop the skills needed to analyze and critique material publicized or used in daily life.

### **Defining Risk**

To be clear, according to Gigerenzer (2014), risk is not equivalent to uncertainty. These are two separate, but related, entities. Riesch (2013) prefers this definition of risk, where “risk refers to a measure of uncertainty combined with the potential outcome” (p. 31). Riesch (2013) also cites Wynne’s (1992) definition of risk as “situations where the outcomes and the probabilities are well known and quantifiable” (p. 33) whereas, uncertainty is further classified into various levels. For discussion purposes in this paper, the Lidskog and Sundqvist (2013) sociological perspective of *risk* will be used which states

The contribution of sociology to the field of risk research is mainly that society is differentiated, which means that also cognitions, understanding, and feelings of risk are differentiated. Actors have various cultural belongings and structural positions which make them understand reality differently, and therefore also act differently... Risk is for sociology always a particular risk situated in a specific context. (p. 77)

In contrast, *technical risk analysis* means to

anticipate potential harm to human beings, cultural artifacts and ecosystems, to average these events over time and space, and to use relative frequencies (observed or modeled) as a means to specify probabilities ... it does not consider

the broader social, cultural, and historical context from which risk as a concept derives its meaning. (Lidskog & Sundqvist, 2013, p. 80)

The remaining sections of this review discusses the key elements that support and impact risk literacy which are adult and higher education, adult literacy, the connection between language and mathematical literacy, innumeracy and mathematical influence on socio-economic inequity.

### **Adult and Higher Education**

One of the foundational pillars of adult education is holistic, meaningful, life-long learning. This phrase implies not only continuous learning but a distinction between *learning* and *education*. According to Jarvis (2010), “learning is a human process that we all undertake from the earliest times of our life, whereas education is a social process that controls and constrains our learning in a wide variety of ways” (p. 17). Grace (2006), in *Critical Adult Education: Engaging the Social in Theory and Practice*, states that

the field of adult education is not only concerned with the holistic practice of adult learning in work, home and within society but critical adult education is preoccupied with how the field of study and practice might become more ethical, just, and inclusive so that it can respond better to the needs and desires of adults who are mediating the demands of home, learning and workplace. (p. 135)

Jarvis (2010), in *Adult Education and Lifelong Learning*, comments that the necessity for life-long learning is threefold:

(a) being exposed to other local cultures is now a lifetime process that engages a process of lifelong learning; (b) due to rapid social change, individuals need to learn new knowledge to prevent the onset of alienation or anomies; lifelong

learning helps [people] adjust to the cultural changes prevalent in society; and (c) the adaption to an ever-changing society, the learning process and all forms of education assist people in processing and adapting to changes throughout their lives. (pp. 16-17)

These goals, however, also encompass numerous contentious issues such as: whose agenda should determine *what* adults should be taught and for what reason? Whose goals are being met? How are these goals to be measured? Who has access to this information and how is it to be shared and used? Jarvis (2010) points out that, “those who control the educational process exercise the major power in teaching and learning since they control the content, so that those who have the greatest social educational needs – the industrialists – have now assumed a very powerful place in society” (Jarvis, 2010, p. 23).

To underscore and illuminate the role of adult education, Collins (2006) remarks that adult education pedagogy, known as *andragogy*, in theory and practice is, “rooted against the claims of capital and the political, economic and social conditions which undermine, on a daily basis, the aspirations and the education of a ‘free’ people” (Collins, 2006, p. 118). In addition, Nesbit (2002), citing Apple (1979) Shor & Freire (1987) and Williams (1976), explains that

Every educational system incorporates biases which reflect the views and interests of those in possession of social, economic, and political power. The notion that all knowledge is socially constructed is central to this view. This [also] means that knowledge is created through interactions with others in specific social, historical, cultural, and political contexts, and therefore, necessarily structured in particular ways. (p. 174)

Macedo (2001; cited in Freire, 2001) remarks that through the selection process specific bodies of knowledge have been given priority over others discouraging and limiting other voices and discourses. The underlying principles of the [curriculum] selection process are based on ideology that appears invisible and claims to be neutral when in fact, it is the opposite. This is evident in curriculum and resources focused on ‘disarticulated technical training over courses in critical theory which enable student to make linkages with other bodies of knowledge to gain a more comprehensive understanding of reality’ (pp. xiii-xiv). This in turn raises the following question, what are the implication for teaching practice and teacher education? Freire (2001), in *Pedagogy of Freedom*, comments that, “teaching requires a recognition that education is ideological; teaching always involves ethics; teaching requires a capacity to be critical, a recognition of our conditioning, humility and critical reflection” (p. xiii). O’Sullivan (2008) observes that many high-achieving Canadian teacher graduates, of middle-class socio-economic status, are employed in the institutions in which they were educated. As such, these graduates are both a product of and raised in the dominant neoliberal ideology and consumer-orientation of the global market society and this impacts teaching practice. O’Sullivan (2008 ) adds that “if an educator’s understanding of how the world works is ‘deficient’, his/her ability to teach insightfully about that world from any perspective much less a critical and transformative perspective will be compromised” (pp. 95-97).

These are a few of the current and on-going issues that ignited decades of debate and research in teaching and educational equity over 50 years ago. Educators at all levels of education, as Freire (2001) states, should be cognizant of the fact that *what* and *how* they were taught and what they currently teach are based on specific ideology with an

embedded value-equity system that is transferred and communicated through the process of education. The fragmentation of understanding that Macedo (2001) referred to above is both a structural element and a bi-product of this ideology, reinforcing educational silos and fragmented curriculum.

Over the last decade, Western institutions of higher education have been reorganized with a business focus. According to Giroux (2016), in “Neoliberal Politics as Failed Sociality: Youth and the Crisis of Higher Education”, Western academic institutions and educational practice are focused on “delivering improved employability, which has reshaped the connection between knowledge and power” (p. 5-6). It has consequently “rendered faculty and students as professional entrepreneurs and budding customers” (pp. 5-6). Grace (2006) makes a similar observation, stating that “critical adult education has critiqued instrumentalized forms of adult education as generally demonstrative of the commodification and tendency toward reductionism shaping the field of study and practice” (p. 134).

The above discussion identified three current issues in the field of education those being: selection of educational content and curriculum development which is not ideologically neutral, teacher education that is steeped in the dominant ideology and lacks critical inquiry, and third, goals of higher-education focused on improved employability potentially reducing the profession of education to skill development. These issue raises further questions such as, how can we solve the ingenuity gap identified by Dixon (2001) when our educational system does not maintain curriculum and resources devoted to the development of critical thinking and inquiry skills? How can we, as a society, expect

teachers to teach critical thinking and numeracy when they are not equipped to do so?  
How do we begin to address an ideology that is so deeply embedded in education?

In response to some of the above questions, Nesbit (2002), citing Frankenstein (1987), explains that “knowledge of basic mathematics and statistics is an important point of gaining real popular, democratic control over the economic, political, and social structures of our society. Liberatory social change requires an understanding of the technical knowledge that is too often used to obscure economic and social realities” (p. 173).

Canada’s current socio-economic reality, according to Bouchard (2006), is that in Canada and globally, “social and economic policy is being shaped with the explicit goal of promoting human capital and the knowledge economy - the acquisition of new knowledge-through education and learning [which] is now seen as the key to the meal ticket of the nation: its economy” (p.165). Is the goal of creating a knowledge economy putting limits on Canada’s future economy to a narrowly defined set of ‘employable skills’ useful to a finite number of employers and thereby exposing the future Canadian economy to systemic risk? Additionally, why is employability/productivity used to determine the value of education and educational goals? How does the public hold politicians and policy makers accountable in a knowledge economy? I believe, these are only a few of the issues that impact education and other disciplines that have undergone this transformation.

### **Adult Literacy: Present and Future**

Taylor and Blunt (2006) state that literacy has shifted from humanistic and citizenship frames to an economic one. More specifically, literacy has been redefined to include the



“capacity to function effectively in the social spheres of work, community, culture, and recreation, including reading, writing, numeracy” (p. 326). Literacy also involves skills required for employment, such as computer and document use and working with others.

According to Gee (1989), literacy is “discourse - a socially accepted association among ways of using language, of thinking, and of acting that can be used to identify oneself as a member of a socially meaningful group or ‘social network’. [These] discourses are inherently ‘ideological’” (pp. 1-2).

Adult literacy is monitored by all OECD countries and most recently, Green and Riddell (2012) conducted research into adult literacy in Canada, Norway and the United States, to examine the relationship between literacy skills (prose, document and quantitative literacy) and age using the 2003 IALSS data. Green and Riddell (2012) found across Canada, Norway and the United States, a consistent decline in adult literacy from 1994 to 2003. The authors observed that literacy strongly increases with years of schooling and parental education level. However, all three countries “show similar patterns of skill loss with age, as well as declining literacy across successive cohorts” (p. 3). The author’s also noted that the Canadian data revealed inequalities in literacy distribution nationally and ranks Canada between Norway and the United States for unequal literacy distribution globally.

In addition, Green and Riddell (2012) examined recent graduates among these three countries and commenting that, “individuals from a given birth cohort lose literacy skills after they leave school at a rate greater than indicated by cross-sectional estimates” (p. 3). Of particular concern, is the cause of the rapid skills loss and further evidence that more recent birth cohorts have lower levels of literacy than those 10 years their senior

among the more highly educated individuals attributing lower literacy levels with “doing a poorer job of educating successive generations” (p. 3).

However this trend requires investigation into the curriculum and education systems of developed countries. As for lower literacy of recent cohorts, this too necessitates further exploration into possible causes and underlying factors more specifically, to identify and address the rapid deterioration of literacy skills in a younger generation. Concerns regarding skills loss however, reiterate the need to address socio-economic views on literacy, curriculum, resources, planning and program development for skill retention after post-secondary education and accessibility.

When examining the effect of declining literacy with increased age and income, Green and Riddell’s (2012) report uncovered that the relationship between literacy skills and age does not follow the assumed universal pattern that is, increased earnings with age and work experience, as is displayed by other forms of human capital. Their findings show a decline in literacy within this population. Green and Riddell (2012) comment that “despite lower literacy levels overall, Canada and the U.S. have also not been able to maintain the skills of successive generations, especially in the middle and top of the skill distribution” (p. 22) and requires analysis of the underlying causes and relationships leading to skill loss.

The OECD and Statistics Canada (2000) published the following adult literacy findings in the *Literacy in the Information Age – Final Report of the International Adult Literacy Survey (LIA)*:

- In 14 out of 20 countries, at least 15% of all adults have literacy skills at only the most rudimentary level, making it difficult for them to cope with the rising skill demands of the information age. Countries with large numbers of citizens at the

lowest level of literacy (with more than 15% on the prose literacy test) are: Australia, Belgium(Flanders), Canada, Chile, Czech Republic, Hungary, Ireland, New Zealand, Poland, Portugal, Slovenia, Switzerland, the United Kingdom and the United States.

- Low skills are found not just among marginalized groups but among significant proportions of the adult population in all countries surveyed. Hence, even the most economically advanced societies have a literacy skills deficit.
- Between one-quarter and three-quarters of adults fail to attain literacy Level 3, considered by experts as a suitable minimum skill level for coping with the demands of modern life and work.

The LIA (2000) report also documents the factors that affect adult literacy such as educational level of parents, further literacy acquisition beyond post-secondary training and skill maintenance through regular used and informal learning (OECD, 2000, p. xiv).

The Canadian Council on Learning (2005) reports that,

forty-two percent of adult Canadian have literacy skills below the level necessary to succeed in today's society and economy. Equally troubling, however, is the lack of substantial progress in adult literacy since the last such survey over a decade ago, despite the significant resources that all levels of government have committed to improving literacy. Ongoing rhetoric about the importance of continuous learning, lifelong learning, life-wide learning, up scaling, workplace training and essential skills from both business and government created an expectation that adult literacy would have risen significantly in the past decade. Yet it hasn't. The percent[age] of Canadians at each prose skill level in 2003 is virtually no different than it was in 1994. (Canadian Council on Learning, 2005, p. 2)

Jewett (2013) provides some insight by explaining that there is an underlying assumption about literacy, that "once students acquire the basic skills to read that this skill is widely

adaptable and applicable to all kinds of texts and reading situations. We believe this is not the case” (p. 19). It is also assumed that when a student acquires basic literacy skills, students are ‘well’ equipped for literacy-related tasks later in life. Jewett (2013) explains that this approach “reflects a basic belief that basic reading skills will automatically grow into more complex reading skills as students advance through grades and disciplinary areas” (p. 19). Jewett (2013) adds that “we do not believe this progression is automatic nor does it always include the reading of print texts or reading that is discipline specific” (p. 19) and becomes problematic when there is insufficient support to develop one’s reading skills.

The development of reading skill is not the only issue in adult literacy. Giroux (1980) argues that given the influence of technology and mass media on literacy, the definition of literacy must change. Giroux (1980) suggests that the definition of literacy expand to not only include the ability to read but to read critically from inside and outside one’s experience with conceptual power that is linked to a theory of knowledge that is politically neutral. This ability enables citizens to critically decode their personal and social worlds. This implies that one learn how to read messages critically and through the process of critical analysis citizens are engaged in true discourse. If one examines mathematics discourse through Giroux’s (1980) lens what would one find?

### **Connection Between Literacy and Mathematics**

Any level of mathematics instruction is mediated through language (Jurak et al., 2016). Ausubel (2000) remarks that “language is an important facilitator of meaningful reception and discovery learning”. Language clarifies such meaning, makes meaning more precise and transferable. Ausubel (2000), views language an “integral”, executing

an “operative (process) role in thinking rather than merely a communicative role” (Ausubel, 2000, p. 5). The ability to create symbols to communicate meaning or value is a function of the language capacity, innate to all human beings, and is the foundation of the creation of abstract symbols used in mathematics for centuries (Dehaene, 2009; Devlin, 2012; Pinker, 2009). Kottak (1982), citing White (1959), states that approximately 500,000 years ago humanity, came into existence when our ancestors acquired the ability to *symbol* that is to assign an object that arbitrarily stands for something else. According to Kottak (1982) the hallmark of human culture is

the ability freely and arbitrarily to originate and bestow meaning upon a thing or event, and, correspondingly, the ability to grasp and appreciate such meaning. To think symbolically, to learn, to manipulate language, to employ tools and other products of cultural traditions in organizing their lives and adapting to their environment. (Kottak, 1982, p. 6)

These symbols, educationally, present different challenges. Adams-Lott (2003) comments that “for students across all grade levels, weakness in their mathematics ability is often due in part to the obstacles they face in focusing on these symbols as they attempt to read the language of mathematics” (p. 786) and reading mathematics is a particular area of challenge.

Furthermore, in daily life Adams-Lott (2003) remarks that, “mathematics is a language that people use to communicate, solve problems, create works of art and mechanical tools. It’s a language of words, numerals, and symbols that are at times interrelated and interdependent and at other times disjointed and autonomous” (Adams-Lott, 2003, p. 786). Correspondingly, Hallady and Neuman (2012) remark that, “reading

and mathematics share common tasks such as making predictions, monitoring understanding, determining importance, making connections and using a flexible problem-solving strategy” (p.471). Halladay and Neuman (2012) further point out that there are many natural connections between comprehension and problem-solving strategies and teachers can assist students to understand the connections using common language to promote strategic thinking (p. 475). Phillips et al. (2009) state that, “mathematics is a language all its own”. In order for the student to comprehend the expression, “the reader needs to understand the symbols represent mathematical concepts” (p.468). Students must be able to “understand the syntax (sentence construction or word order) because each word and symbol in mathematics text must be read and understood with precision. In short, reading in mathematics is dealing with two languages simultaneously” (Phillips et al., 2009, p. 468).

To better understand the math-language relationship an examination of the traits, qualities and characteristics is important. Adams-Lott (2003), citing Wakefield (2000), states that the following characteristics of mathematics qualify it as a language:

1. Abstractions (verbal or written symbols representing ideas or images) are used to communicate
2. Symbols and rules are uniform and consistent
3. Expressions are linear and serial
4. Understanding increases with practice
5. Success requires memorization of symbols and rules
6. Translations and interpretations are required for novice learners
7. Meaning is influenced by symbol order

8. Communication requires encoding and decoding
9. Intuition, insightfulness, and “speaking without thinking” accompany fluency
10. Experiences from childhood supply the foundation for future development
11. The possibilities for expressions are infinite (Adams-Lott, 2003, p. 786)

When one has a better understanding of how language informs, guides, and instructs mathematical thinking one can better appreciate the complexity of mathematical thinking, the time required and process involved in developing this skill.

To clarify, Nesbit (2002) remarked that, “numbers and number systems are, like language, a fundamental feature of human activity,” (p.175) but when one speaks about numeracy, referring to mathematical ability, it involves the use of symbol, numbers and number systems to perform mathematical calculations. It is this use in science and technology that determines the economic productivity of an industrialized society. In other words, to be numerate is synonymous with being mathematically literate. Johnson (2013) explains that being *literate* in a discipline involves acquiring the discipline knowledge and applying key theoretical concepts in similar ways to their application in the field. It requires critical reflection and questioning, and an understanding of the process to answer those questions and to competently communicate this information. However, to become numerate one must understand what the challenges are.

Language challenges to student learning in mathematics occur in different areas at different times. These challenges are also different in nature, scope and impact students in different ways. For example, in observation of the use of mathematical language, Kotsopoulos (2007) reports that students have difficulty understanding mathematics

when they experience *interference* in three different areas. According to Kotsopoulos (2007), interference occurs when language is borrowed from daily life and used in the mathematical world (the mathematical register), words such as *cancel, if, limit, table*. This type of interference is referred to as *Student-talk Interference*. Kotsopoulos (2007) states that “students must continually and actively negotiate among the mathematical meaning of a word, its everyday language meaning, and its new meaning as well as its alternative meanings within the mathematical register” (p. 302). Kotsopoulos (2007) found that students also experience *interference* from the predominant use of the mathematical register by the teacher called *Teacher-talk Interference*. Students also experience *interference* from within the Mathematical Register itself called *Textual Interference* which “arises when students are not able to discern the appropriate use of a particular word or term from the mathematical register because they are not able to make sense of the mathematical context” (p. 304). On closer examination, challenges in language-mathematics use surface in the area of mathematics instruction where in observation of mathematical instruction Boulet (2007) noted specific illustrations of mathematics instruction to encourage teachers to carefully examine the language they use in the classroom. Boulet (2007) comments that, the language used to describe long division was “cryptic and impedes meaningful problem solving” (p. 4). Moreover, Boulet (2007) comments that, when “the procedural aspects of computation [are] overemphasized without clear conceptual understanding of the place value system, students tend not to think about the meaning of what they are doing and simply parrot someone else’s directions in order to perform calculation” (p. 4).



Boulet (2007) has identified one of the potential ways gaps in student learning occur. By repeating instruction without comprehension may be employed by students as a coping mechanism to deal with student frustration when they cannot grasp the concept or, an inability to communicate how they do not understand, and potentially as a response to or an intuitive awareness of expectation and peer pressure. Furthermore, Boulet (2007), citing Bonotto (2005), comments that, these gaps in mathematical learning continue into adulthood as demonstrated by studies of pre-service elementary teachers' understanding of decimals. The study "identified significant difficulties in interpreting decimal numbers and solving word problems involving decimals" (p. 6). Furthermore, "the introduction of more and more rules to be able to connect mathematical ideas at the symbolic level becomes unmanageable and is often at the root of students' claim that mathematics is irrelevant and abstract" (Boulet, 2007, p. 6).

In essence, the accumulation of these gaps in understanding creates a cascade effect that can become overwhelming and unmanageable and students can potentially react as Boulet (2007) describes. When these gaps in learning are combined with differences in language use in social interactions inside and outside the mathematics classroom this adds yet another layer of challenge in the learning process.

Citing Bernstein (1971), Jurdak, Vithal, de Freitas, Gates, and Kollosche (2016) remark that, "different social groups use different codes of language and the exclusive use of the elaborated code of the middle class in school causes the reproduction of social inequalities, systematically hindering other student from educational success" (pp.10-11). This is another level of language interference that exists in the mathematics classroom. Jurdak et al. (2016) state that,

Students with low-economic status are systematically excluded from success in mathematics education by the wide-spread use of language which is intelligible for high but misleading for low socio-economic status students. This has been thoroughly documented in studies which apply Bernstein's theory of language codes in pedagogic practice (Jurdak et al., 2016, p. 11).

This is an example of a situation in which language use in mathematics can exclude students and impede their learning. This unconscious action is what calls mathematics educators to be emotionally intelligent, cognizant of their actions and biases in their language use in the classroom, and to develop an awareness of the treatment of their students. Furthermore, according to Jurdak et al. (2016) this awareness and action also extends to mathematics curriculum, texts, evaluation and administration.

The use of language in mathematics is a complex and nuanced issue. As students progress into adulthood, a different level of mathematic skill is required to function independently especially when exposed to significantly more numeric data reported in the media, in work-related material, health professional offices and on tax forms. Dion (2014) stresses that the mathematics of daily life is not the same mathematics taught academically – the content and focus is entirely different from the OECD's perspective. The lack of clear distinction between STEM mathematics and the intentions and purposes of mathematics for daily living, I believe, is a relevant confounding factor to the innumeracy discussion.

### **Innumeracy and Contributing Factors**

As mentioned previously, Nesbit (2002) remarked that mathematical ability is a key component to scientific and technological development which is fundamental to

economic progress and viewed as ‘cultural capital’. Nesbit (2002) comments that “numeracy levels in society are regularly monitored by educators, government, and business leaders in both North America and Europe” (p. 177). Paulos (2001) makes the following points about innumeracy:

- Our mathematical problems result more from an insufficient exposure to mathematics as a way of thinking and a set of intricately connected higher-level skills than from an inability to compute.
- Almost everybody can develop a workable understanding of numbers and probabilities, of relationships and arguments, of graphs and rates of change and of the ubiquitous role these notions play in everyday life.
- Real world examples of innumeracy are stock scams, choice of spouse, newspaper psychics, diet and medical claims, risk of terrorism, astrology, sports records, elections, UFOs, insurance and law, psychoanalysis, parapsychology, lotteries, and drug testing. (p. xiii-4)

According to Paulos (2001), innumeracy is caused generally by “blocks to dealing comfortably with numbers and probability [that] are due to natural psychological responses to uncertainty, to coincidence, or how a problem is framed” (p. 5).

Additionally, *innumeracy* is broadly defined as “an inability to deal comfortably with the fundamental notions of number and chance that plagues far too many otherwise knowledgeable citizens” (Paulos, 2001, p. 3). Furthermore, Gigerenzer (2014) defines innumeracy as “the inability to think with number. Like illiteracy, innumeracy is curable. It is not a mental defect inside an unfortunate mind, but due to lack of education” (p. 270). According to Gigerenzer & Edwards (2003), innumeracy cannot solely be ascribed

to the student, adding that “statistical innumeracy is often attributed to problems inside the mind. We disagree: the problem is not simply internal but lies in the external representations of information, and hence a solution exists” (p. 741).

There are numerous sources and causes of innumeracy from misconceptions and illusions of certainty (Gigerenzer, 2014), to poor question framing and decision making (Kahneman, 2013), systems of education, math anxiety, poorly trained teachers, poorly written text books, to general misconceptions about mathematics, and misconceptions publicized by the media. Paulos (2001) mentions several other causes of innumeracy from poor early mathematics education, to teacher training and judgmental errors reproduced by the media. Jurdak et al. (2016), identify how mathematics textbooks also contribute student innumeracy because the perspective of math texts written for “high socio-economic status students that prepares them to become sovereign masters of mathematics”(p.11).

In contrast to the textbooks written for students of low socio-economic status that “merely fosters the submissive recognition of the superiority of mathematical approaches” (Jurdak et al., 2016, p.11) and not mathematical thinking.

In addition, Jurdak et al. (2016) comment on the poverty of experience and lack of opportunity to use mathematical skills between students of different socio-economic status stating that, “what we do now know is school mathematics is quite different from workplace mathematics. Because mathematics is ‘shaped’ by the workplace context, rather than procedural, this leaves them [students] unprepared for tasks in which mathematics is embedded and functional” (p. 27) so that if students do not receive an

opportunity to consistently practice, outside the classroom, to reinforce their mathematics skills these skills will be lost and this too is a contributing factor to innumeracy.

Another consideration regarding innumeracy is the availability of resources and support to help students negotiate the philosophical shift from procedural mathematics, taught at the elementary and secondary level with prescribed steps, to thinking mathematically. Devlin (2012) comments that “before college you succeed in math by learning to ‘think inside the box’ but at college, success in math comes from learning to ‘think outside the box’” (p. viii). Devlin (2012) states that the first step to being successful in negotiating the transition from secondary school to college mathematics is to “learn to stop looking for a formula to apply or a procedure to follow or template and to think about the problem. Not the form it has but what it *actually* says”(p. viii). The goal of college math “is to develop the thinking skills that will allow you to solve novel problems (practical, real-world problems) for which you don’t know a standard procedure” (Devlin, 2012, p. viii).

Devlin’s (2012) comments raise additional questions such as, do all students have access to the institutional support to help them transition into ‘mathematical thinking’ and to maintain those skills? Secondly, like differences in language use, are mathematics textbooks inclusive and reflective of differences in language comprehension? Moreover, is the innumeracy debate only about developing and maintaining a pool of highly-trained knowledge workers to draw on or are there other factors/consideration involved in innumeracy? Can innumeracy be reduced by shrinking the income inequality gap?

As recent studies demonstrate declining literacy with age in Norway, Canada and the United States, according to Green and Riddell (2012), does that also equate to

declining numeracy as well? Should we assume that an individual who has completed a program using STEM mathematics also has an understanding of risk when investing or deciding on a surgical procedure? How do we address declining adult literacy and numeracy?

### **Mathematics as a Social Filter and Equity**

How is mathematics used as a social filter and an instrument in socio-economic equity?

Nesbit (2002) remarks that mathematics is generally viewed as “the ultimate body of absolute, timeless, and objective truth far removed from the concerns and values of humanity” (p. 176). Nesbit (2002) explains that mathematics “represents the most certain part of human knowledge” forming the basis of scientific and technological advances. As such, mathematics also “serves central function as a tool of those with power in society” (p. 176). Paulos (2001) raises the issue that a disproportionate number of women limit their employment options because they avoid college mathematics. According to Paulos (2001),

Women, in particular, may end in lower-paying fields because they do everything in their power to avoid a chemistry or an economics course with mathematics or statistics prerequisites. I’ve seen too many bright women go into sociology and too many dull men go into business, the only difference between them being that the men managed to scrape through a couple of college math courses. (Paulos, 2001, p. 106)

In addition, Paulos (2001) remarks that viewing mathematics as a social filter promotes innumeracy. Further commenting that, “mathematics is sometimes endowed with a coercive character which is somehow capable of determining our future” and that

“attitudes such as these certainly predispose one to innumeracy” (p. 121). To clarify Paulos’ (2001) point, if one takes the position that challenges in learning mathematics cannot be overcome, or that mathematics is the only influencing factor in one’s future, are incorrect assumptions. Furthermore, to not attempt to learn mathematics or to give up on mathematics prematurely leads to innumeracy. Paulos’ (2001) emphasizes and reemphasizes the need that everyone and anyone can and should learn the statistics and probabilities that impact daily life. It is how mathematics is employed in society, outside the classroom and the learners’ use and control, that becomes problematic and this distinction needs to be made.

Gates and Vistro-Yu (2003), Frankenstein (2014), Nesbit (2002) and Jurdak et al. (2016) assert that mathematics is used to establish or maintain socio-economic inequality through mathematical achievement in a variety of ways. For example, Jurdak et al. (2016) state that, “mathematics education is a social institution which is inseparably linked to power” (p. 10) and that several groups have their own interest and agenda where mathematics education is concerned from “mathematicians and scientists, education researchers, politicians, teachers, students and parents are interested in mathematics education for various reasons” (p. 10).

This implies that “the social influence of many of these cultural groups depends on the existence and legitimization of mathematics education, while other cultural groups see their future social opportunities determined in the mathematics classroom” (p.10-11). From this perspective, “mathematics education can be understood as a ‘gate-keeper’ deciding who is allowed or not allowed to pursue higher goals in education or profession” (Jurdak et al., 2016, pp. 10-11).

In addition, Jurdak et al. (2016), citing the OECD 2013 report, states that “socio-economically advantaged students and schools tend to outscore their disadvantaged peers by larger margins than between any other two groups” (p. 23). Jurdak et al. (2016) adds that “indeed this is a sobering thought that economics, income inequality or socio-economic status is more significant in explaining differences in mathematics achievement than gender and race” (p. 23). As such, the subject of mathematics serves as both an instrument of socio-economic selection and an educational imperative of society.

As mentioned above, Paulos (2001) acknowledges that very bright women put themselves at an economic disadvantage when they don’t take one or two statistical prerequisite courses to enter into college business programs. Jurdak et al. (2016) mentions another element in mathematics education that reinforces socio-economic difference and that is the ‘white male math myth’ which is “a regime of truth ascribing mathematical intelligence to the white male population only” (p. 11). In addition, instructor personal biases “toward or against certain ethnic populations impacts mathematics education by assuming that certain ethnic populations are assumed to be capable or incapable” (p.11). The bias communicated within “society or through low financial and human support for the schools in their neighbourhoods” reinforces social class and social stratification (Jurdak et al., 2016, pp.11-12). Gates and Vistro-Yu (2003) state that “there [will] always exist groups who will argue that real mathematics can be taught only to those who can be successful at a particular formulation of mathematics. This promotes the creation of a marginalized group in mathematics” (p.47).

In addition to reinforcing socio-economic difference, mathematics has a history of being used as a filtering instrument in higher education through the use of high-stakes



entrance examinations. Nesbit (2002) remarks that “in most countries, passing examinations in mathematics is necessary for access to higher education (and hence to higher-paying work) regardless of the area of future study” (p.177). Furthermore, the “possession of mathematical knowledge is seen as governing learners’ future occupational and economic roles. In this way, mathematics becomes ‘cultural capital’ indicative of future economic success” (Nesbit, 2002, p. 177).

Filtering by entrance examination is employed by post-secondary institutions globally. High-stakes examinations such as SAT, MCAT, GMAT, LSAT, GRE, to name a few, invariably include a significant mathematics component. The resulting exam score has a direct influence on entry into professional and doctoral programs, fields of study and career direction. According to Ennis (2001), scores on high-stakes examinations only demonstrate students’ test taking ability, not critical thinking. Butterworth (2001) adds that although students can perform higher-level computational tasks through rote learning, this does not constitute understanding or mathematical thinking. Upon further exploration, Gates and Vistro-Yu (2003) researched the impact of examination cultures and high stakes examinations. Citing Bourdieu (1988), Gates and Vistro-Yu (2003) observed that exam results are

Often [delivered] with a psychological brutality, which nothing can attenuate, the school institution lays down its final judgements and its verdicts, from which there is no appeal, ranking all students in a unique hierarchy of forms of excellence, nowadays dominated by a single discipline, mathematics. Those who are excluded are condemned in the name of a collectively recognized and

accepted criterion (and thus one which is psychologically unquestionable and unquestioned), the criterion of intelligence. (Gates & Vistro-Yu, 2003, p. 42)

This statement demonstrates the use of mathematics to filter groups and the direct impact and devastating effect that exclusion and labelling have on human beings. Yet, as educators we are specifically trained and warned about excluding and improperly labelling students because of the potential psychological trauma it can cause.

However, in most academic institutions today, students have been given administrative tools to address and appeal grades but there still can exist undercurrents or elements of doubt in students' minds about their intelligence because of this "collectively recognized and accepted criterion" that cannot be questioned.

From a societal and community perspective, Gates and Vistro-Yu (2003) comment that, in some countries "the use of mathematics to select so-called key people, useful individuals for whatever purpose, has resulted in the creation of an elite group of learners tagged as 'gifted' or of superior intelligence" (p.42). And in doing so, an arbitrary "division has created undue bias against those who 'cannot do mathematics' and scars these people for life" (p. 42). Hence, the administration and outcome of these examinations can potentially have life altering, permanent repercussions producing socio-economic and class stratification. Gates and Vistro-Yu (2003) further add that, a "significant portion of the population has been incorrectly labelled and disenfranchised when they cannot meet the prescribed mathematics criteria" (p. 42).

Within education management and mathematics pedagogy, Gates and Vistro-Yu (2003) investigated discriminatory practices within the mathematics classroom and curriculum management where educators identified several issues. They remark that "any

discussion of equity in the mathematics classroom has to include the insidious practice of ability discrimination” (p.59), also referred to as “‘setting’ in the UK, ‘tracking’ in the USA, ‘streaming’ in Singapore” (p.59). More importantly, recognition that it is “how we as a mathematics education community conceptualize the way in which ability discrimination might be understood as a cultural phenomenon” and that “ability segregation is not just of interest where it occurs but it is also of interest where it does not” (Gates & Vistro-Yu, 2003, p. 59). Zaslavsky (1981), in Gates and Vistro-Yu (2003), summarizes by stating that “it is the content and methodology of the mathematics curriculum that provides one of the most effective means for the rulers of our society to maintain class divisions” (p. 47).

To summarize, the equity discussion in this section responded to Paulos’ (2001) comment that viewing mathematics as a social filter promotes innumeracy and discussed inequity in the mathematics classroom, curriculum and administration which are all potential contributing factors to innumeracy. Paulos’ (2001) statement has been contradicted by Ennis (2001), Gates & Vistro-Yu (2003), Jurdak et al., (2016) and Nesbit (2002) who have documented the outcomes of the instrumentalization of mathematics in the classroom to act as a social-economic filter, to stratify society along socio-economic lines, to create and maintain inequity by the use of different texts and language, used principally by the dominant socio-economic group, that inhibits learning and excludes individuals leading to irreversible economic and psychological harm. As a result of this discussion, it has now become apparent that there are many actors who play a part in the instrumentation of mathematics. Jurdak et al. (2016) state that, although the “mathematics education research community might want to frame the debate on mathematics

achievement around cognitive development, identity, curriculum, teaching style etc. we are up against a much bigger problem – growing income inequality” (pp. 23-24).

From this discussion, it is clear that mathematical achievement/innumeracy debate is not simply about the performance of individuals or cultural groups or a matter of taking math courses – there are socio-economic and socio-political interests also at play in the issue of numeracy.

### **Adult Mathematics Education**

Recent data from Statistics Canada, OECD, Green & Riddell (2012) and others demonstrate that adult literacy and innumeracy has not improved over the last decade and will have a significant impact on the Canadian economy. Dion (2014) emphasizes that it is important to make the distinction between mathematics for the STEM fields (Science, Technology, Engineering and Mathematics) and Numeracy. Dion (2014) states that, “numeracy involves the deployment of the basic math skills learned in formal schooling in a flexible and goal-oriented way. This can involve performing basic operations like addition and subtraction to estimation, measurement, proportions, ratios and statistical literacy used in daily life” (p. 8). Dion’s (2014) points out that “numeracy should be deemed an essential skill to be integrated into all discipline areas” (p. 19) – not just mathematics for STEM subjects. Dion (2014) re-emphasizes that it is important to be conscious of two different *streams* of mathematics with different goals and criteria. Numeracy, evaluated by the OECD, is based on different criteria than STEM mathematics, where numeracy is content and discipline specific. Moreover, Dion (2014) remarks that our perceptions need to change regarding how we view mathematics for living and STEM math. This dichotomy is echoed throughout the mathematics and adult

education literature between mathematics that is *functional* and *marketable* versus theoretical.

For example, Devlin (2012), commenting on college mathematics, explains that mathematical thinking for the twenty-first century requires Type 2 ability. That is “people who can take a new problem, in manufacturing for example, [and] identify and describe key features of the problem mathematically, and use that mathematical description to analyze the problem in a precise fashion” (p. 8). Devlin (2012) further explains that in “today’s world, where companies must constantly innovate to stay in business, the demand is shifting toward Type 2 mathematical thinkers- to people who think outside the mathematical box, not inside it” (Devlin, 2012, p. 8).

Ramus-Safford (2008) observed that, in the United States, ‘numeracy’ is replaced by ‘quantitative literacy’ in collegiate mathematics. In the review by the National Council on Education and Disciplines (NCED) report, *Mathematics and Democracy: the Case of Quantitative Literacy*, the NCED argues that citizens of the 21<sup>st</sup> century need strong mathematics skills in the modern world in the areas of citizenship, culture, education, professions, personal finance, personal health, management and work. In order to service these needs, citizens need the numeracy skills of arithmetic, data, computers, modeling, statistics, chance and reasoning (Ramus-Safford, 2008, p. 14).

Based eight essays on adult quantitative literacy, Ramus-Safford (2008) concluded that the competencies that quantitatively literate adults should possess are “the ability to argue with numbers, to use fractions and percent in everyday life, to function in the business world, to research and organize quantitative data and to think critically about public issues” (p. 14). Ramus-Safford (2008) noted that the competencies not found on

the National Mathematics Panel competency list are problem-solving heuristics, modeling, logic and reasoning, cooperative work, and statistical literacy and raises the concern that, “it is the disappearance of statistics and downgrading of probability that I find most troubling. In their roles as citizens and workers, adult students are increasingly called on to comprehend statistical data and arguments” (Ramus-Safford, 2008, p. 15) and these concerns are also shared by Ottaviani (2002), Gal (2002), and Paulos (2001) as well. Dougherty and McInerney (2009) remark that in today’s consumer society, “it is impossible to evaluate the safety of new drugs, household products or toys or anything else until you have a great deal of information” (p. 31). What is most often missing from publicized data and reports is information relating to the population size from which mortality and morbidity data are taken. Dougherty and McInerney (2009) comment that, “without those numbers – the denominators against which meaningful comparisons can be made- the data are not helpful in rational risk analysis” (p. 31). Another example by Evans (2012), raises these questions regarding risk and climate change:

How can citizens make informed decisions about such matters if they are not equipped to think clearly about risk and uncertainty? Without the tools to understand the uncertainty surrounding the future of our climate, we are left with a choice between two equally stupid alternatives – ignorant bliss or fearful paralysis. High levels of risk intelligence will be required among the general population if we are to deal effectively with any of the big challenges that humanity faces in the twenty-first century. Climate change is a case in point. (Evans, 2012, p. 615).

According to Ottaviani (2002) “the modern citizen must deal with masses of quantitative data which may at times be contradictory which require of him or her a minimum awareness of how such data is collected, organized, analyzed and interpreted” (p. 31). Ottaviani (2002) explains that numeric data, frequently used to report official statistics, involves numbers and techniques where the problem of definitions – for example, labour force, employment or unemployment rates, birth rates, poverty rates, bank rates and rates of infection – are statistical terms utilized in daily life that are defined and understood by demographers and socio-economic statisticians. Furthermore, statistical illiteracy is evident in the explanation of medical tests and procedures provided by medical practitioners. Gigerenzer and Edwards (2003) comment that “doctors with an average of 14 years of professional experience were asked to imagine using the Haemocult test to screen for colorectal cancer” (p.741). Of those doctor’s participating in the study, “one half estimated the probability as 50%, when the correct response is 5%” (p. 741). Gigerenzer and Edwards (2003) remark that “we know of no medical institution that teaches the power of statistical representations; even worse, writers of information brochures for the public seem to prefer confusing representations” (p. 741). To clarify how other sources of statistical confusion arise, Ottaviani (2002) remarks that, “critical skills are not sufficient because most citizens have no control over the data they hear or read about and the way data is collected. So decision making is reduced to whether to trust or not trust the information source” (Ottaviani, 2002, p. 31).

From the examples cited above, the application of mathematical thinking in daily life is far more apparent and one that warrants greater attention and support. Discussion in this section focused on the type of mathematics adult learners need to function in the

twenty-first century. The lack of data with respect to mathematical literacy in higher education and numeracy education in non-STEM discipline areas in post-secondary education has been raised by Dion (2014) is a concern but more importantly, is the need to reposition/reintroduce numeracy within all disciplines and change the attitude toward mathematics as exclusively a STEM subject. Far more contentious is the social filtering and equity issues that surround mathematics teaching, content and administration. In addition, debate continues on what mathematics adults should learn to address the real world challenges for the 21<sup>st</sup> century. As discussed throughout this review, statistical literacy is foundational to assessing and evaluating risk – the basis for this curriculum unit on risk literacy. There are many parallels between risk and STEM mathematics; for example, risk is a specialized field of mathematics only accessible through expert knowledge and requires specialized skills and training. This review opened with the discussion of why the everyday person needed to have an understanding of risk and that (risk) knowledge resides within a small group of experts who are not widely accessible to the public. Risk also uses a technical language that only a few, until recently, can understand and interpret, and so understanding risk can appear to be restricted/inaccessible and remain largely unknown. I believe the same factors of inequality in mathematics, discussed in the previous pages, can also potentially impact adult numeracy and risk education.

### **Chapter Summary**

The preceding literature discussed what risk is, why it was important and how it was relevant to daily life. Our ability to become risk literate, from my perspective, is based on critical adult education, the language-mathematics connection, adult literacy and



numeracy, and is impacted by the socio-economic inequity at play in mathematics education. Risk literacy is not found, so far, in the currently published mathematics curriculum at the elementary, secondary, or post-secondary level. The author did not have access to private elementary, secondary or post-secondary curriculum to review for this project.

The distinction between technical risk and sociological risk was defined. In this project, risk and risk literacy is approached from and taught in a sociological perspective that is “risk situated in a specific context” (Lidskog & Sundqvist, 2013, p. 77) to give numerical values meaning and develop understanding (Macedo, 2001).

This paper sought to demonstrate and emphasize the connection between literacy and numeracy. Numeracy and mathematical thinking is built upon and cannot exist without literacy and is based on the human linguistic capacity to symbolize (Adams-Lott, 2003; Dehaene, 2009; Devlin, 2012; Kottak, 1982; Nesbit, 2002). Recent studies of adult literacy by OECD and Statistics Canada (2000) have reported no significant improvement in adult literacy since 1994 (Canadian Council on Learning, 2005); in fact, Green and Riddell (2012) reported declining adult literacy rates in Norway, Canada, and the United States among recent graduates and those at the higher income levels. Nesbit (2002) reiterates that governments, corporations, NGO’s, routinely monitor literacy and numeracy, which are used as indicators of the country’s ‘cultural capital’ and future economic potential.

Also discussed in this review were issues surrounding teacher education. O’Sullivan (2008) voiced concern that recent high-achieving Canadian graduates, who have grown up, been educated and employed in middle class environments are rooted in

the ‘dominant neoliberal ideology and consumer-orientation’ (p. 95). O’Sullivan (2008) asks how critical or transformative can the actual classroom practice be when teachers are not aware of the dominant ideology, power dynamic and class system they are a part of? I believe this is a valid question for mathematics education as well.

Innumeracy in the literature tended to focus on the mathematics alone; in this paper, I hoped to demonstrate that innumeracy is impacted by, and is the result of, declining literacy and the systemic inequalities in mathematics education and mathematics curriculum in elementary, secondary and post-secondary education (Gates & Vistro-Yu, 2003; Giroux, 2016; Jurdak et al., 2016; Nesbit, 2002) which impedes student learning, public engagement and action in a democratic society.

Our encouragement is that innumeracy (as well as illiteracy) can be addressed and is not a defect of the mind or due to an unfortunate set of circumstances (Evans, 2012; Frankenstein, 2014; Gal, 2002; Gigerenzer & Edwards, 2003; Gigerenzer, 2002, 2014; Gates & Vistro-Yu, 2003; Jurdak et al., 2016; Nesbit, 2002; Ottaviani, 2002; Paulos, 2001; Rosenthal, 2005; Ropeik, 2010; Spiegelhalter, 2008, 2009, 2012). Risk is communicated to the public in the form of probability (a statistic) but the public’s ability to deal with and evaluate risk is based on the statistical and language literacy which has been found to be declining or insufficient to address risk or to become risk literate (Evans, 2012; Gigerenzer, 2002, 2014; Ropeik, 2010; Spiegelhalter, 2009, 2012).

This chapter summarized the current research, issues and discussions in adult and mathematics education that play a role in forming the basis of risk literacy instruction for this curriculum unit. Chapter Three will address the methodology and model used to develop the risk literacy curriculum unit.

### **CHAPTER THREE: METHODOLOGY AND PROCEDURES**

This study on adult learning in risk literacy was designed to produce a means to teach and address risk illiteracy and to examine some of the educational barriers to developing adult numeracy and critical thinking. The purpose of the study is to create discourse that engages learners on a pragmatic and practical level through the topics, exercises and materials provided in the curriculum unit. The intention is not to produce calibrated measures of goals, motivation and efficacy but to educate learners to develop tools to comprehend and navigate the plethora of often confusing and conflicting risk information on health, society, economy and the environment present in the social sphere of the twenty-first century.

#### **The Culture of Risk Taking**

The awareness that one is living in and part of a risk culture can be astonishing at first. Many times, I've heard that 'without risk there is no reward'. Taking risks is important for human learning and social development, but at what cost? For example, Klein (2010), in *Addicted to Risk*, looks at risk and the environment on multiple levels, two in particular stand out. Klein (2010) referring to the BP Oil Deepwater Horizon, Gulf of Mexico, April, 2010 and the Exxon Valdes spill, Prince William Sound, Alaska in March, 1989, examined the dominant narrative of oil exploration of industrialized countries. Klein (2010) remarks that industrialize countries appear to claim domination over Mother Nature; that is to say, there is an inexhaustible supply of natural resources and that if we create a natural disaster/mess we can use technology to fix it.

Klein (2010) states that the belief that technology can correct mistakes such as these, is a myth. Secondly, oil extraction techniques such as fracking and strip mining, tar sands extraction, are high risk activities that put human health and the environment at risk. Klein (2010) comments that these activities are allowed to take place because they are the “‘perils of privilege’ where ‘greed and hubris are intimately intertwined to create vastly overconfident bankers/financiers who are encouraged to take even greater risks in the future” (p. 3). Klein (2010) remarks that the “perils of privilege brings us closer I think, to the root of our collective recklessness. Whether we actively believe them or consciously reject them, our culture remains in the grips of certain archetypal stories about our supremacy over others and over nature”.

In another example, Harvey (2010), in the *Crisis of Capital*, points out that British Economists, when questioned by Her Royal Majesty Queen Elizabeth, about the 2008 Financial crisis responded that they did not see crisis coming because they missed/did not consider *systemic risk*. Systemic risk is defined as

The possibility that an event at the company level could trigger severe instability or collapse an entire industry or economy. Systemic risk was a major contributor to the financial crisis of 2008. Companies considered a systemic risk are called “too big to fail”. These are very large institutions relative to their respective industries and make up a significant part of the overall economy. A company that is highly interconnected with others is also a source of systemic risk.

(Investopedia, 2016)

Harvey (2010) remarks that the economic crisis of 2008 is the same economic problem that existed in the 1970’s just repeating itself forty-five to fifty years later. Harvey (2010)

states that the problem lies in the excess of capital in the hands of very few creating tremendous economic imbalance. Dr. Harvey (2010) concludes that he understands the nature of the problem but remarks that he does not see us [the public] debating and discussing these economic issues.

This curriculum unit is derived from personal and professional experience as a graduate student and business educator. As an educator, and in my own professional development I have identified gaps in understanding and communicating risk that are so vitally important on a personal, professional and social level that it could not be ignored any longer.

Hence, my post-secondary teaching experience, knowledge of adult education, personal reflection and my observation of students led to a deeper investigation into the topic of risk and its relevance.

### **Process of Development**

As a business instructor, I assumed that students in my classes understood and could communicate risk was from a business perspective. My assumption was incorrect. I also realized that I was not adequately equipped to discuss or teach it to students, nor did I have the tools to do so. I embarked on the journey to find the resources and edify myself. In other words, I needed to become risk literate. Thus, the impetus for this project arose from the need to understand risk on a personal and professional level. This unit is formulated based on two working hypotheses:

H<sub>0</sub>1 = A relationship exists between language, statistical and risk literacy

H<sub>0</sub>2 = Risk literacy can be taught and understood with the use of critical thinking, inductive reasoning, heuristics and basic statistics for decision making

The previous chapter discussed where and how risk literacy was relevant to the individual and used by professional and governments that involved decision making on issues of finance, environment, health and public policy. Paulos (2001) comments that “without some appreciation of common large numbers, it’s impossible to react with the proper skepticism to terrifying reports that more than a million American kids are kidnapped each year” (p. 9) that people need only to have a basic understanding of statistics and risk to be able to put these numbers into context. Gal’s (2002) suggest a model of statistical literacy that involves two groups of elements: (1) *knowledge elements*, such as literacy skills, statistical and mathematical knowledge, context knowledge, critical questions; and (2) *dispositional elements* of belief and attitudes and critical stance (p. 4). However, Gigerenzer (2014) remarks that knowledge of statistics is not sufficient for decision making. Adding that, using heuristics (rules of thumb) is a more effective method for making complex decisions in short periods of time.

Gigerenzer (2002, 2014), Gigerenzer & Edwards (2003), Paulos (2001) and Spiegelhalter (2009) all comment that one the most significant contributing factors to risk illiteracy is perception and miscommunication of risk. Ropeik (2010) comments that “risks have personality traits that help us instinctively judge their character” (p. 141-2). Furthermore, whenever the choice involves both risk and benefit, the greater the benefit, the more we play down risk in our minds. The smaller the benefit, the greater the risk is likely to seem. This is called a *risk perception gap*. In addition, Ropeik (2010) and Spiegelhalter (2009) state that our comprehension, communication, and decision making are directly influenced by our risk perception. According to Ropeik (2010), how we perceive risk is not just a matter of the statistical or scientific facts, it is a matter of

perspective, and that perspective is powerfully informed by how we compare the risk versus the benefits. These factors, individually and in combination, can make us feel more or less afraid. If there is little perceived benefit, the associated risk will look bigger. Furthermore, our perception of risk is also influenced by society, peer group, culture and religion. Awareness of these factors can help one to understand and uncover what governs our decision-making.

This curriculum unit incorporates Gigerenzer's (2002, 2014) risk literacy instruction along with Gal's (2002) model of statistical literacy, which includes both the knowledge and dispositional elements. The information is screened through the risk perception factors outlined by Ropeik (2010), which employs critical thinking, decision making with heuristics and the adult education dispositions to form a model of risk literacy (see Figure 1). Figure 1, presents a proposed model of risk literacy, each discipline area informs and is informed by risk literacy and operates as feedback system. Information can move in cyclical, non-cyclical, staggered or random direction but it is an interconnected within the system. This system is made fluid by reasoning skills.

### **Reasoning Skills**

What fuels this risk literacy model is reasoning skills. Goel (1997) states,

Reasoning is the activity of evaluating arguments. All arguments involve the claim that one or more propositions (the premise) provide some grounds for accepting another proposition (the conclusion) and these arguments are sorted into two broad categories – inductive and deductive – based on the nature of the relationship between premise and conclusion. (p.1305)

Arthur (2001) argues this point, “what do we do when deductive reasoning (and rationality) break down?” Arthur (2001) comments that, “deductive rationality breaks down under complication” for two reasons. First, “beyond a certain level of complexity human logical capacity ceases to cope – human rationality is bounded” (P.406). Secondly, Arthur (2001) adds that deductive reasoning works only when problems are clearly defined. He further adds,

Modern psychologists are in reasonable agreement that in situations that are complicated or ill-defined, humans use characteristics and predictable methods of reasoning. These methods are not deductive, but *inductive*. (Arthur, 2001, p.406)

Simon (1994), explains that “the characterization of justifications as inductive and deductive is incomplete. The quest of mathematics learners to understand mathematics and to determine mathematical validity leads not only to inductive and deductive reasoning, but also to a third type of reasoning” (p. 2), which is transformational reasoning. According to Simon (1994), when students engage in transformational reasoning,

they are seeking a sense of how the mathematical system in question works. Such knowledge is often the result of “running” the system, not to accumulate outputs as in an inductive approach, but rather to develop a feel for the system. I call this *transformational reasoning*. (p. 3)

This curriculum unit engages all three types of reasoning skills: deductive, inductive, and transformational. The method(s) used to calculate risk depend on the type of data collected and the context in which the data are used. Exploring text with different representations of number is intended to increase students’ level of ‘comfort with



numbers’ as discussed by Paulos (2001) as one of the criteria used to determine the numeracy. Therefore, the best approach to teaching fragmented subject matter, in my opinion, is through case studies that provide an understanding of the calculation of risk in different contexts. This curriculum unit is a series of case studies used to explore risk in various environments and its possible manifestation(s) in our daily lives through the process of context/content analysis, isolation of the variables for calculation of probability and risk, and then to examine the meaning of these results in context – within a classroom or an electronic classroom setting.

One of the challenges for students is understanding that calculating risk does not follow a straight line – at times, the dots do not directly connect and there are no definitive solutions, but this does not invalidate the process or result. The second challenge is the anxiety attached to the need to find ‘one right answer’ when there are multiple interpretation or when no clear solution presents its self immediately. Instructors should have an appreciation for and experience with managing student anxiety associated with new learning (Brookfield, 2006,) redirecting students’ attention to remaining open to different possibilities and interpretations would be more advantageous. It is important that both student and instructor become comfortable with ambiguous and/or anomalous results. Conversely, some would argue that the presences of ambiguous/anomalous results are indeed ‘a valid’ result in certain contexts.

The unit is a series of case studies designed to engage problem solving, critical thinking, using context analysis, identifying and isolating relevant arguments. In cases where data collection is involved, data can be entered into a spreadsheet or database. In some cases an electronic workbook can be used for the calculation of probability, risk,

discussion and analysis. The unit requires that learners are ready to use and familiar with micro computers, software applications (Word, Excel, PowerPoint) with approximately two years of experience. Instructors should have an intermediate to advanced level of software application(s) experience to lead students in application use and analysis.

Several other software applications such as Gapminder, MS Access and FilemakerPro which have database capabilities (manipulation/calculation/data management) and graphing capability can be used instead of Excel. The choice of software application is flexible and based on available resources within the institution and instructor experience.

However, the unit is flexible and incorporates materials that can be used in both electronic and hard copy formats. Students' mastery of skill is demonstrated through an independent summative project to be assigned at the instructor's discretion. It should be noted that this unit is not intended to be used to teach remedial reading/literacy skill, although it can be modified to accommodate that purpose, the minimum language literacy level of students for this resource should be in the range of high Level 2 to 3 according to the Ontario Adult Literacy Curriculum Framework, 2011 (OALCF).

One of the goals of this unit is metacognition through the use and development of creative and critical thinking, mathematical thinking, language literacy, computer literacy and collaborative work to explore current events, debunking myths, to expand and develop adult numeracy and risk literacy. This curriculum unit is not intended to replace any STEM mathematics program, but components of this unit can be used to augment and support STEM mathematics. This unit would be of interest to educators and administrators of second-career and continuing education programs in colleges, as well as

university and college educators in the fields of environmental, health and social sciences, business, technology and mathematics.

### **Evaluation of Curriculum Unit**

The proposed curriculum unit should meet or exceed the existing risk literacy education. A lesson on risk was given to a panel of four reviewers: an elementary teacher, former college business professor, insurance consultant, and secondary school principal, with a questionnaire that consisted of seven questions. The reviewers were asked to go through the lesson and provide written feedback on different aspects of the lesson such as: Are the objectives for this lesson clear and well stated? Is the assessment type and level appropriate? Do the activities adequately demonstrate and reinforce the concepts discussed in the lesson? Reviewer Feedback was summarized (see Chapter Five) and content recommendations were implemented where applicable. A copy of the Reviewer questionnaire is in Appendix D. The conclusions, recommendations, and implications of the evaluation of the curriculum unit are discussed in Chapter Five.

### **Limitations**

Qualitative data collected through questionnaires from the reviewers was summarized and the similarities and difference were noted. One of the limitations of the evaluation of this curriculum unit is that it has not been fully implemented before the completion of this paper. It is hoped that future feedback on this unit will make it feasible to implement in a post-secondary setting. As well, it is important to bear in mind that revisions and modifications of this unit are necessary to meet not only the learners' needs but to incorporate updates to subject area, content and electronic links. Another potential limitation for the use of this curriculum unit is teacher training and access to technology

for both instructor and learners. Although one of the objectives of this unit is to enable educators to deliver curriculum, it may become apparent after its evaluation that supplemental training is required to fully utilize this unit. Nevertheless, the development of this curriculum unit is a first attempt and an acknowledgement of the need for risk literacy instruction for adult learners.

### **Expected Findings**

This project is not experimental in nature, and so a hypothesis is not a direct derivative of this process. As such, however, some outcomes could reasonably be expected to occur. It is hoped that this curriculum unit is adopted in a post-secondary setting. It would be expected that this unit would be adopted by instructors in non-STEM programs and incorporated into the curriculum for risk instruction. It would then be likely to observe improved performance, behaviour and learning from those students who teachers have used these methods.

This chapter examined the methodology and procedures which formed the basis of development for this curriculum unit on Risk Literacy Using Case Study and Probability to Teach Risk to Post-Secondary Students in Non-Stem Programs. Chapters Two and Three provide the theoretical foundation for creating similar curriculum units as seen in Chapter Four. Chapter Four contains the entire Curriculum Unit.

## **CHAPTER FOUR: CURRICULUM UNIT**

### **Unit Plan Overview**

#### **Purpose and Unit Context**

This curriculum unit is designed to introduce and develop risk literacy for adult learners using case studies to foster comprehension of probability and risk and problem solving in specific context. This unit was designed to introduce risk to second year college or university students enrolled in arts and science or social science programs.

#### **Unit Summary**

In this unit on Risk Literacy, students will explore the connection between context, mathematical thinking, language and risk by examining risk expressed in demographic, business, scientific and medical articles in the form of case studies to comprehend the meaning of risk in context and to develop a heuristics for risk evaluation. Students research, analyze and identify how risk is communicated and expressed using a variety of electronic and printed materials, video as well as journal articles. In this unit, students will also be required to use numeric data, statistics, graphs, organizers, maps, visual aids, spreadsheets and various forms of writing to present their findings.

The unit outline consists of eleven lessons which will consume approximately nine to twelve, 180 minute periods and a summative evaluation. Throughout the unit, students will be engaged in discussion and a number of hands-on learning activities that are designed to develop and advance their inquiry, research and communication skills. By the end of this unit, students should be familiar with why risk is important, how it is communicated, converting probabilities to natural frequencies, and how to evaluate commonly found forms of risk.

This unit is designed to engage students' critical and metacognitive thinking skills and inductive, deductive, and transformational reasoning. Students will require use of electronic resources to check sources, refine and practice their research and analytical skills as such, most lessons in this unit incorporate the use of computers and internet, group discussion and analysis, as well as independent work. This unit takes an interdisciplinary approach and meets several cross curricular expectations from other discipline areas.

## Overall Expectations

By the end of the unit, students will:

- ☑ Identify risk communicated in various forms of media (electronic and print) and its relevance to daily human activity
- ☑ Identify risk expressed as rates or percentages.
- ☑ Identify language that obscures and confuses the meaning of written expressions of risk in print and electronic media
- ☑ Relate how the language used to communicate risk can produce confusion and how these numeric values can be misread and misinterpreted
- ☑ Use primary and secondary sources to locate information about the specific contexts to clarify and support or disprove risk claims
- ☑ Use graphic organizers, media works, oral presentations, written notes, descriptions, drawings, tables and graphs for context analysis, communicate key information and generate a list of context specific heuristics
- ☑ Use appropriate vocabulary to describe their inquiries
- ☑ Use a variety of sources (e.g. graphic organizers, graphs, charts, tables, drawing, slide shows, notes) to explain and demonstrate risk in context
- ☑ Identify and discuss the relationship between language and mathematics
- ☑ Demonstrate and discuss the use of Concept Maps and graphic organizers to aid acquisition, retention and meaning making of statistical and numeric data
- ☑ Identify and describe innumeracy and mathematical thinking and its relevance to comprehending risk
- ☑ Research, compare and graphically demonstrate expressions of risk from two different forms of media
- ☑ Identify and describe math anxiety and strategies to overcome math anxiety
- ☑ Convert rates and percentage to natural frequencies to explain risk
- ☑ Develop a method or scale to evaluate risk

## **Cross Curricular Connections**

### **Language & Communication Arts:**

#### *Find and Use Information*

- Find, select and evaluate sources of information as well as read and interpret individual sources of information. Information sources may be written in sentences and paragraphs, displayed as documents, or produced as films, broadcasts, or presentation.
- Interpret documents. Document make use of different formats and structures, and can include lists, tables, forms, diagrams and maps. Use graphics that provide a visual summary of quantitative information, such as pie and bar charts, and line graphs.
- Extract information from films, broadcasts and presentations
- Use a variety of appropriate visual aids to support or enhance presentations

#### *Communicate Ideas and Information*

- Discuss topics and opinions, present information and explain how to carry out tasks
- Generate ideas about a potential topic using a variety of strategies (e.g. brainstorming)
- Gather information to support ideas for writing, using a variety of strategies, and oral, print, and electronic sources
- Complete and create documents of different formats and structures which can include lists, tables, forms, diagrams, maps, visual summary, charts and graphs

### **Numeracy & Data Management:**

- Adds, subtracts, multiplies, and divides whole numbers and decimals
- Recognizes values in number and word format and makes simple estimates
- Interprets and represents values using whole numbers, decimals, percentages and simple common factions
- Comparing, calculating, displaying numerical data, creating graphs to display numerical information. Counting and comparing numbers of items, calculating summary statistics (e.g. averages), graphing measures over time, and using statistics and data patterns to make predictions
- Extract and interpret numbers in texts with sentences and paragraphs
- Interprets simple, common probabilities such as the chance of precipitation from a weather forecast
- Collects, organizes and represents data using simple tables and graphs
- Recognizes patterns and begins to identify trends in data (e.g. population, crime, demographic, inventory data)

**Reasoning & Thinking Skills:**

- *Analogical Reasoning* - form of inference that allows us to derive implications from single cases even when we do not know all the factors involved (Klein, 1987)
- *Critical Thinking*: Interpretation, analysis, inference, evaluation, explanation, self-regulation (Facione, 2011)
- *Deductive Reasoning* – Hypothesis testing - a logical process to formulate a specific conclusion drawn from generalized information based on mathematical proof
- *Inductive Reasoning* – logically evaluating arguments that containing one or more premises to form a specific conclusion; identification of patterns to formulate hypotheses or schemata to be tested in different environments to form broader generalizations-known as heuristics
- *Transformational Reasoning* – mental or physical enactment of an operation or set of operations on an object or set of objects which allows one to envision the transformations that these objects undergo and the set of results of these operations – a dynamic process by which a new state or a continuum of states are generated (Simon, 1994)
- Categorizing, relational mapping, synthesizing information, reflection

**Prior Knowledge:**

- Grade 10 mathematics (minimum)
- Research, presentation and communication skills, literacy – high level 2 to 3 (minimum)
- Computer and software literate – Internet research. Word and PowerPoint 2010 or 2015



**Curriculum Unit Plan**

**Risk Literacy – Using critical thinking, case study and probability**

**Dianne J. R. Kenton**

## **Lesson #1: Exploring Context**

**Description:** Students will explore and engage in group discussion to examine, analyze and evaluate information to describe/map the context and to examine the statistical information contained in articles. Secondly, small group discussion will focus on summarizing, identifying patterns and themes and critically assess the author's claims.

### **Objectives:**

- To make students aware of how people find and use numbers to support their arguments
- Familiarizing students with statistical values in text (ratios, percentages, probabilities)
- Identify how numbers are used and information is conveyed
- What concepts of risk can be identified? Is there a risk and is it clearly communicated?

### **Activity:**

1. **Review and discuss the online articles as a class on tornado prediction noting the following:**
  - a. **Context (using worksheet)** – What are tornados? Where do tornados occur? What time of year do tornados occur? In what geographic locations? What factors are involved in the development of tornados? How does tornadic activity impact humans? Are there risks? Can the risks be clearly identified?
  - b. **Prediction (in groups)** – How are tornados predicted? Using the articles and websites below can you find a pattern of activity/location/direction/time of year?
2. **Discussion of group findings (as a class)**
3. **Questioning (solicit feedback from students on meaning of numbers in text) -**  
Was the information clear or conflicting? Did you understand what all the numbers meant? Can you express the same ideas in a better way? What other information do you need? What do you want to know more about?
4. **Brainstorming research questions** – Students to generate samples of research questions they are interested in

**Articles:** Tornado Prediction – Predicting the unpredictable

- 1) <http://newsfeed.time.com/2012/03/07/tornado-season-how-do-meteorologists-predict-twisters/>
- 2) <http://www.scientificamerican.com/article/improving-tornado-prediction/>

### **Assessment:**

Student record reflection and discussion using the Exploring Context worksheet

**Resources:** (see Appendix B)

Exploring Context worksheet

- <http://www.theverge.com/2013/5/23/4358728/the-science-of-tornado-prediction-moore-oklahoma>
- <http://www.almanac.com/content/predicting-tornadoes-radar-screen>
- <http://canadatornado.com/ontario/history/>
- <http://news.nationalgeographic.com/news/2014/04/140428-tornado-prediction-warn-on-forecast-science/>
- National Weather Service – Storm Prediction Center <http://www.spc.noaa.gov/>

## Lesson #2: Math Anxiety and Numeracy

**Description:** Students will be introduced to the concept of math anxiety and examine how math anxiety impact numeracy through video, group discussion and analogy. Student will explore articles on math anxiety and strategies to address it. Group discussion on strategies to overcome math anxiety will be presented informally in class.

### Objective:

- Identify sources and potential causes of math anxiety
- Discuss and develop strategies
- Discuss the potential impact of math anxiety on numeracy

### Activity:

1. **View and Discuss** YouTube on Math Anxiety article and discuss
2. **Brainstorming & group strategizing** – list strategies on flip chart paper in groups
3. **Practice reframing** questions
4. **Research Question:** What are the odds of being struck by lightning?

### Articles:

- Ahdoot, R. (2013). Conquering Math Anxiety. TEDx AJU. *YouTube*. February, 2013. <https://www.youtube.com/watch?v=66y4W5HervQ>
- Butterworth, B. (2001). *From the fear of fractions to the joy of maths*. [www.mathematicalbrain.com](http://www.mathematicalbrain.com)
- Lightning Map

### Assessment:

- Group work sheet with math anxiety suggestions
- 1-2 page reflection paper on what is math anxiety and innumeracy? Why is it important? How does innumeracy impact decision making? What does this information mean to you and how do you act on it?

### Resources: (see Appendix B)

- [www.lightningmaps.org/realtime?lang=en](http://www.lightningmaps.org/realtime?lang=en)
- Wagner, D. (2014). False Alarm Raises Suspicion. Newsletter. *Canadian Mathematics Educators Study Group*. Vol.30, No. 2.

### Lesson #3: Exploring the Relationship Between Language and Mathematics

**Description:** Students will explore the relationship between language and mathematics and how the facility of language makes mathematical learning possible. Activity and discussion will illustrate common terms from natural language used in mathematics can become confusing requiring students to read materials critically. Student will discuss and explore language strategies to aid mathematics learning.

#### Objective:

- Familiarizing students with statistical values in text (ratios, percentages, probabilities)
- Identify how numbers are used and information is conveyed
- Discuss and explore the importance of language use in mathematics
- Practice critical reading of numbers in text and identify improper or misused terms

#### Activity:

1. **View and Discuss** – YouTube video Devlin’s “How humans acquired the ability to do math?”
2. **Group Activity** (in small groups) - draw (a) from a written math problem and (b) math problem using natural language.
3. **Using numbers to support arguments** (using Boston Globe article) – student write a brief statement of their opinion about nuclear power.
4. **Research Question** – In what other situations or circumstances do you find confusion of terms? What images does it create in your mind or what does it communicate to you? How could this be addressed or corrected?

**Article:** Devlin, K. (2012). How did human beings acquire the ability to do math? *YouTube*. Stanford University. October, 2012.  
<https://www.youtube.com/watch?v=NnVubBrATIU>

#### Assessment:

- Nuclear Power Opinion Piece – 1 page
- Short Essay (3-4pgs): What do you understand mathematical thinking to be? What promotes mathematical thinking? What capacity allows humans to do math? Why was math developed?

#### Resources: (see Appendix B)

- Two Triangles – example of transformational thinking.
- Opinion Piece - Boston Globe & Dept. of Energy
- Essay Rubric

### Lesson #4: Context Analysis – A Method to Understand Risk

**Description:** Student practice research and assess articles that discuss risk in groups and to map the context using a context worksheets, graphic organizers to explain the concept or meaning of the expressed risk. Group discussion will include miscommunication of risk and language strategies that could be used to facilitate comprehension and meaning making.

**Objective:**

- Understanding and observing how risk is communicated in text and in media
- Identify and discuss the contextual elements that inform and communicate risk to the reader
- Familiarizing students with statistical values in text (ratios, percentages, probabilities)

**Activity:**

- 1) **Discussion** (group) – What is Body Mass Index? What does it measure? How is it used? Practice calculating BMI
- 2) **Questioning** - What message is communicated in the article. Can it be clearly and immediately be understood? How is risk being communicated? Can you explain what it means? How do you interpret risk? What do you understand risk to mean?
- 3) **Exploring Context** – (in groups) Describe or map, using Exploring Context worksheet, the context of an article that expresses risk

**Articles:**

- 1) Spiegelhalter, D. J. (2014). *Eating Bacon Sandwiches is bad for you? Evaluating Risk.*  
<https://motivate.maths.org/content/MathsHealth/Risk/video/BaconSandwiches>
- 2) Katz, D. (2015). Meat and Cancer – hammering at the memo.  
[www.linkedin.com/pulse/meat-cancer-hammering-memo-david-l-katz-md-mph](http://www.linkedin.com/pulse/meat-cancer-hammering-memo-david-l-katz-md-mph)
- 3) Canadian Diabetes Association. Body Mass Index and risk of diabetes.  
<http://www.diabetes.ca/diabetes-and-you/healthy-living-resources/weight-management/body-mass-index-bmi-calculator>

**Assessment:**

- Individual assignment – Current Events – select online article that uses or states risk and provide analysis of context using graphic organizers.
- Group submission of electronic or written graphic organizer to demonstrate analysis of context of a selected article to show: (i) Analysis of situation (ii) identify assumptions (iii) Isolate and evaluate expressions of risk and stated probabilities
- Submission of group case analysis

**Resources:** (see Appendix B)

- Exploring Context worksheet
- BMI Chart

## Lesson #5: Numeracy and Mathematical Thinking

**Description:** Students review, examine and construct mathematical statements. Students practice to apply percentages and then convert percentages to probability statements.

**Objective:**

- Constructing mathematical statements following rules of syntax
- Using numerical information to apply percentages and converting percentages to probabilities
- Develop meaning making and relevance of probability concept by connecting probabilities students calculate in class to current events and articles previously read in class.

**Activity:** 1) Writing mathematical statements – What are the objects used? How are statements constructed i.e. syntax?  
 2) Application of Percentages  
 3) Converting Percentage to Probability Statements  
 4) Locate statements of probability in articles - have students now identify and explain the probabilities identified earlier or now see in their diagram.

**Article:** Devlin, K. (2014). Introduction to Mathematical Thinking with Keith Devlin. *YouTube*. Coursera. July, 2013. <https://www.youtube.com/watch?v=YFs06zgBfMI>

**Assessment:**

- Refer to group submission Lesson 4

**Resources:** (See Appendix B)

- Three faces of Probability
- Examples of probability statements
- Applying percentages case
- Converting percentages example



## Lesson #6: Risk Communication

**Description:** Students will define and discuss what risk is, how it used and communicated. Students will examine and compare various forms of risk miscommunication from different fields. Students be introduced to the concepts of certainty and the illusion of certainty progressively working towards developing heuristics for decision making in Lesson 8.

### Objective:

- Define risk – social and technical and its role in society
- Define and differentiate risk from uncertainty
- Discuss and identify various forms of risk miscommunication
- Experiment with communicating risk using diagrams and manipulatives

### Activity:

- 1) **Presentation** – Using slides for Lesson 6, introduce how risk is used in our society and why is it important?
- 2) **Review & Discuss** YouTube videos – What do you understand risk to be?
- 3) **Review and discuss Risk Miscommunication** – Identify sources and methods of miscommunication of risk and potential results.
- 4) **Article Review** (groups) – research or use a previously sourced article on risk to identify any forms of potential miscommunication

### Articles:

- 1) Klein, N. (2010). Addicted to Risk. *TEDWomen 2010*. TED Talk [www.TED.com](http://www.TED.com) <https://www.youtube.com/watch?v=0ZhL7P7w3as>
- 2) Wright, L. (2015). Many Canadian entrepreneurs lacking in basic financial knowledge. *Business. Toronto Star*. [www.thestar.com/business/2015/01/26/many-canadian-entrepreneurs-lacking-in-basic-financial-knowledge.html](http://www.thestar.com/business/2015/01/26/many-canadian-entrepreneurs-lacking-in-basic-financial-knowledge.html)

### Assessment:

- Group discussion on forms of risk miscommunication
- Article checklist submitted by group to evaluate article for risk miscommunication

### Resources: (See Appendix B)

- Risk Literacy Lesson 6 – PowerPoint
- Causes of Risk Miscommunication
- Risk Communication Table
- Miscommunication Checklist
- Terms and definitions (see Appendix A)

### Lesson # 7: Evaluating Risk – Given Relative Risk (Part II)

**Description:** In groups, students will explore a case on breast cancer risk to evaluate risk in the breast cancer literature that does not state a given probability. Student will use the tools from lesson one to six to discuss and explain the patient's risk of having breast cancer given a high false-positive screening rate.

**Objective:**

- Identify the four ways risk is represented
- Identify expressions of relative and absolute risk
- Isolate and identify risk perception factors
- Rewrite statements in terms of absolute risk

**Activity:**

- 1) **Presentation** – Using slides for Lesson 7
  - a) Difference between Risk and Uncertainty
  - b) Expressions of risk in the form of relative and absolute risk
- 2) **Review & Discuss** YouTube videos – What do you understand risk to be?
- 3) **Review and discuss Risk Miscommunication** – Identify sources and methods of miscommunication of risk and potential results.
- 4) **Article Review** (groups) – Summarize in small groups, use the Risk Communication and Perception Tables to list and identify in an article

**Articles:**

- 1) Toronto Star, Health and Wellness, 2015: 'US Study predicts 50% rise in Breast Cancer'
- 2) Spiegelhalter, D. J. (2012). *If you can calculate risk you can make better judgements*. YouTube. <https://www.youtube.com/watch?v=XjTMgA2ENBY>
- 3) Canadian Cancer Society. Breast cancer. <http://www.cancer.ca/en/cancer-information/cancer-type/breast/breast-cancer/?region=on>
- 4) Calculation of Relative Risk (Wikihow) [www.wikihow.com/Calculate-Relative-Risk](http://www.wikihow.com/Calculate-Relative-Risk)

**Assessment:**

- Article summary (small group)
- 1-2 Page summary identifying risk miscommunication, type of risk used and possible risk perceptions.
- Illustrate the probability/risk using diagrams, decision tree, concept map

**Resources:** (See Appendix B)

- Risk Literacy Lesson 7 – PowerPoint
- Relative Risk Exercise – Part 1
- Risk Perception Table
- Forms of Risk Communication Table
- Risk Literacy – Terms & Definitions

## **Lesson # 8:** Evaluating Risk – Converting Probability to Natural Frequency (Part II)

**Description:** In groups, students will continue to explore a case on breast cancer risk, in part 1, to evaluate risk using a given probability. Student will use the tools from lessons one to seven to discuss and explain the patient's risk of having breast cancer. Student work on taking known or given probabilities and converting probabilities to natural frequencies put in context.

### **Objective:**

- Convert probabilities to natural frequency
- Restate the probability of an outcome in terms of a natural frequency in context
- Articulate and define the difference between relative and absolute risk
- Illustrate expression of probability as a natural frequency using diagrams, drawings or concept maps

**Activity:**

- 1) **Presentation** – Using slides for Lesson 8, introduce how risk is used in our society and why is it important?
- 2) **Instruction:** Converting probability to natural frequency
- 3) **Review and discuss:**
  - i. **Risk Miscommunication**
  - ii. **Questions to ask** (What is the Absolute risk? What is the population size (denominator) and Age group?)
- 4) **Article Review** (groups) – Summarize in small groups discuss and compare the likelihood of death from breast cancer versus cardiovascular disease.

### **Articles:**

- Spiegelhalter, D. J. (2014). *Eating Bacon Sandwiches is bad for you? Evaluating Risk.*  
<https://motivate.maths.org/content/MathsHealth/Risk/video/BaconSandwiches>
- Heart & Stroke Foundation: Canadian women and Cardiovascular disease  
[http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3484041/k.D80A/Heart\\_disease\\_\\_Women\\_and\\_heart\\_disease\\_and\\_stroke.htm](http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3484041/k.D80A/Heart_disease__Women_and_heart_disease_and_stroke.htm)
- Cardiovascular disease and North American women

### **Assessment:**

- Article summary (small group)
- 1-2 Page summary identifying risk miscommunication, type of risk used and possible risk perceptions.
- Illustrate the probability/risk using diagrams, decision tree, concept map

### **Resources:** (See Appendix B)

- Risk Literacy Lesson 8 – PowerPoint
- Relative Risk Exercise – Part 2
- Forms of Risk Communication Table
- Risk Literacy – Terms & Definitions

## **Lesson #9: Critical Thinking, Decision-Making and Heuristics**

**Description:** Students work toward developing a summary of criteria based on their analysis to formulate heuristics for decision making purposes.

### **Objective:**

- Summarize discussion on Lessons 7 and 8
- Group presentations on article analysis
- Reflection on content of articles i.e. data. Language, background information

**Activity:** 1) **Review & Discuss** – Summarize Lessons 7 and 8. What conclusions can be drawn from breast cancer studies and statistics? What did student learn about breast cancer information? Are there any reliable sources of information?

2) **Influence of Risk Perception & Heuristics** – discuss and become acquainted with the factors. Can students identify areas in which both bias, risk perception and/or heuristics may play role in the articles they read?

3) **Article Review** (groups) – Summarize in small groups, use the Risk Communication and Perception Tables to list and identify in an article. Students to brainstorm suggestions on how to make their own choice of doctor.

### **Assessment:**

- Group submission of Exploring context worksheet

### **Resources:** (See Appendix B)

- Heuristics (Rules of Thumb)
- Forms of Risk Communication Table
- Risk Perception Table
- Risk Literacy – Terms & Definitions
- Decision Making

### **Lesson #10:** Case Study – Self-Study

**Description:** Using the process and resources from lessons one to nine students will analyze a case of their choosing that involves risk. Students will use lists, tables, forms, diagrams, maps, spreadsheets, graphing software, organizers, or PowerPoint presentations to tell/explain their selected case on risk. Students can work independently or in pairs and then present their work to their peers.

**Objective:** To research, analyze, compare, evaluate and hypothesize the risk in the chosen topic of investigation and to articulate, write, model and demonstrate the evaluation and decision making process.

**Activity:** Students should use the materials provided in lessons one to nine and follow the same steps to complete the project.

**Articles:** To be determined by student selection

**Resources:** To be determined by student selection

**Evaluation:** (See Appendix B)

- Summative evaluation rubrics

**Lesson #11:** Project 2 – Alternate Self-Study

**Project 2** (Advanced): Using Paulos' algorithmic model, students examine risk impact by scaling risk using a safety index. Different scales can be created based on the context and students will experiment and recalibrate their scales accordingly to be able to articulate and communicate risk impact.

**Objective:** To research, analyze, compare, evaluate and hypothesize the risk in the chosen topic of investigation and to articulate, write, model and demonstrate the evaluation and decision making process.

**Activity:** Students should use the materials provided in lessons one to nine and follow the same steps to complete the project.

**Articles:** To be determined by student selection

**Resources:** To be determined by student selection

**Evaluation:** (See Appendix B)

- Summative evaluation rubrics

## **CHAPTER FIVE: EVALUATION, IMPLICATIONS, FURTHER RESEARCH AND CONCLUSIONS**

The purpose of this study was to develop a curriculum unit for educators to use to develop risk literacy using case analysis, probability and critical thinking to develop decision-making skills. This unit is designed to facilitate and engage students in risk, research, analysis, use of statistics and probability and visualization of data for decision making.

### **Evaluation of Lesson**

A group of independent reviewers, three females and one male, were asked to evaluate a lesson on risk and respond to a questionnaire (see Appendix C). Respondents held occupations in elementary education, administration, financial services and post-secondary business education. The questionnaire revealed that overall, the lesson was well-constructed, sparked interest and also raised the respondents' awareness about risk miscommunication and how numeric information can be misunderstood. Respondents all agreed that the lesson demonstrated progression and had a logical flow that they could follow; this would help them make effective comparisons to better understand the terms and concept of 'absolute risk reduction' in order to successfully work through the case.

Respondents also agreed that resources and background information provided for the case were appropriate and necessary to provide the required information for the context, to follow the argument, to comprehend the data, to make comparisons and meaningful sense of the data. The use of visual materials, charts and tables used in the lesson were very important for comprehension and gave respondents a stable basis of comparison from which to draw/make conclusions.

A Respondent commented that

The chart with the three common forms of communication that create confusion and miscommunication was organized well and colour coded for quick reference and understanding. The examples helped to magnify the problems one may experience with the percentages (Reviewer #2, Appendix C).

All respondents agreed with the type and appropriateness of the assessment for the lesson remarking that the assessment allowed the learner to assess themselves and whether or not or not they can determine risk. Reviewer #1 commented,

The assessment offers a chance for the reader to review understanding of the information provided by the article and then check their application of the concepts of risk against the information provided (Reviewer #1, Appendix C).

Respondents all agreed that the activities used in the lesson demonstrated and reinforced the concepts taught. Two respondents noted that they observed the difference in their understanding of the numeric values when they went through the process of evaluating statements of risk in the lesson. In fact, one respondent remarked that it required re-reading the statement two or three times to clearly understand what the article was communicating but when the same information was rephrased as a natural frequency, their understanding of the numeric data was immediate.

### **Implications**

This study confirms that when probabilities and percentages, used to express risk, are expressed as natural frequencies, respondents can comprehend risk in a meaningful way. The unit takes a pragmatic approach, using examples from a variety of daily issues that are current and accessible to respondents, which allowed them to process and



assimilate textual material very quickly. Nevertheless, numeric values, even for literate individuals, require focus, concentration, reasoning and engaged critical thinking – requiring the use of System 2 Thinking (Facione, 2011; Gigerenzer, 2014; Kahneman, 2013; Roeser, 2013) to arrive at a conclusion.

Respondents reported using the resources provided, such as terms and definitions, forms of risk communication table and relative risk examples, to clarify their understanding demonstrating the need and utility of supporting material.

The unit is designed as a resource to develop adult risk literacy and indirectly to facilitate decision-making. Evaluation by the respondents revealed that risk comprehension is not influenced by gender or age. It also confirms that risk literacy requires contextual material and the visual representation of data which is vital to comprehension. Furthermore, risk literacy can be achieved by learners from different occupational backgrounds who do not have detailed prior working knowledge; therefore, this curriculum unit can be adapted teach risk literacy to a very broad audience with few limitation. Respondents shared the opinion that this is a pragmatic skill applicable to daily life and that with practice this skill can improve.

### **Future Research**

Further investigation into causes, approaches and methods to address adult innumeracy, especially after formal post-secondary education, are needed. Based on the literature, additional discussion and identification of adult learner needs, especially in the area of numeracy, needs to take place on a consistent basis in order to develop a strategy for the development of numeracy and decision making skills. Although not discussed in detail in this paper, the matter of access to resources continues to impact adults to this

day and will impact adult numeracy through access to continued educational resources in the future. The impact of socio-economic inequity within mathematics education, along with its impact on the mathematic curriculum, instruction, resources, teacher education and use as a socio-economic filter must be examined and discussed further, as this too also has a direct impact on adult education in a democratic society. On-going access to adult education, especially in the area of numeracy, requires resources and support, and requires further investigation into the impact the lack of access has on learning and what concrete action can be taken.

Lastly, questions arose from the literature that relate to the educational priorities that need to be addressed. Attitudes toward teacher education, expectations about teaching skills and goals of teaching cannot be focused solely on an economic agenda if we are looking to educate engaged literate citizens. Re-examination of the competing agendas that have made their way into the classroom may be the first place to start.

### **Conclusions**

The issue of adult innumeracy is on-going and efforts over the last two decades have not improved declining adult literacy, which plays a direct role in adult innumeracy. This curriculum unit was designed as a resource for instructors to develop and address adult risk literacy and decision making at the post-secondary level. The survey respondents, an independent group consisting of educators, administrators and financial services professionals, found the objectives, activities, materials and assessments of the lesson were useful to learn, comprehend and make decisions involving risk. The respondents agreed that there is a need for clear risk communication and after completing

the lesson, reported a change in their understanding of risk. It is hoped that this curriculum unit will become a useful resource in the post-secondary classroom.

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## APPENDIX A: Definitions and Terminology

**Andragogy:** Andragogy is a theory developed by Knowles (1913-97) differentiates the needs of adult learners from those of juveniles and uses the term andragogy to describe the specific methods which should be employed in the education of adults.

- The adult learner moves towards independence and is self-directing. The teacher encourages and nurtures this movement.
- The learner's experience is a rich resource for learning. Hence teaching methods include discussion, problem-solving etc.
- People learn what they need to know, so that learning programs are organized around life application.
- Learning experiences should be based around experiences, since people are performance centered in their learning.
- Andragogy requires that adult learners be involved in the identification of their learning needs and the planning of how those needs are satisfied. Learning should be an active rather than a passive process. Adult learning is most effective when concerned with solving problems that have relevance to the learner's everyday experience (<http://www.andragogy.org>).

**Absolute risk reduction:** The difference in actual events from the year previous minus the actual events from the current year divided by 1000 determines the probability of the success of the treatment. **Probability of success** = (# yr. prev. - # current yr.)/1000

**Critical Thinking:** Entails the examination of those structures or elements of thought implicit in all reasoning: purpose, problem, or question-at-issue; assumptions; concepts; empirical grounding; reasoning leading to conclusions; implications and consequences; objections from alternative viewpoints; and frame of reference. Critical thinking — in being responsive to variable subject matter, issues, and purposes — is incorporated in a family of interwoven modes of thinking, among them: scientific thinking, mathematical thinking, historical thinking, anthropological thinking, economic thinking, moral thinking, and philosophical thinking (<http://www.criticalthinking.org/pages/defining-critical-thinking/766>).

**Decision Theory:** A branch of statistical theory concerned with quantifying the process of making choices between alternatives. Decision Theory ([http://www.merriamwebster.com/dictionary/decision theory](http://www.merriamwebster.com/dictionary/decision%20theory)).

**Experimental probability:** Probability calculated based on observed results of an experiment

**Franklin's Law:** The only thing one can be certain of is death and taxes (Gigerenzer, 2002).

**Innumeracy:** Refers to “an inability to deal comfortably with the fundamental notions of number and chance” (Paulos, 2001). Involves ignorance of risk, miscommunication of risk, and clouded thinking (Gigerenzer, 2014).

**Literacy:** Is the control or use of secondary language in secondary discourses that occur in schools, workplaces, stores, government offices, business and churches (Gee, 2009).  
(2) To be literate in a discipline means not just accumulating knowledge about the discipline, but applying the important theoretical ideas in ways similar to their application in the field by asking the same types of questions, knowing the processes to answer those questions and being able to communicate successfully within the discipline (Johnson, 2007).

**Mathematical Literacy:** Is an individual’s capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (PISA, 2012).

**Numeracy:** Refers to a broader, more inclusive measure of mathematical skills and conceptual mathematical knowledge (IALSS, 2005)

**Odds:** Expressed as 'how often an event will not occur'. Not the same as probability.

**Precautionary Principle 1:**

The precept that an action should not be taken if the consequences are uncertain and potentially dangerous. Precautionary principle. (n.d.). *Collins English Dictionary - Complete & Unabridged 10th Edition*. Retrieved January 02, 2015, from Dictionary.com website: [http://dictionary.reference.com/browse/precautionary\\_principle](http://dictionary.reference.com/browse/precautionary_principle)

**Precautionary Principle 2:** The precautionary principle or precautionary approach to risk management states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is not harmful, the burden of proof that it is not harmful falls on those taking an action. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result. *Wikipedia the Free Encyclopedia*. Retrieved 1/2/2015, from ([http://en.wikipedia.org/wiki/Precautionary\\_principle](http://en.wikipedia.org/wiki/Precautionary_principle))

**Probability:** The number of times a specific event(s) can occur out of the total possible number of events

**Probability Theory:** The theory of analyzing and making statements concerning the probability of the occurrence of uncertain events. (Probability Theory. (n.d.). Dictionary.com Unabridged. Retrieved January 02, 2015, from Dictionary.com website: ([http://dictionary.reference.com/browse/probability\\_theory](http://dictionary.reference.com/browse/probability_theory))



**Probability equation:** Where  $(s)$  = number of times a specific event occurs,  $(t)$  = total possible number of events.  $p = s / t$

**Prospect Theory:** Kahneman and Tversky (1979) found empirically that people underweight outcomes that are merely probable in comparison with outcomes that are obtained with certainty; also that people generally discard components that are shared by all prospects under consideration. Under prospect theory, value is assigned to gains and losses rather than to final assets; also probabilities are replaced by decision weights. Decisions subject to risk are deemed to signify a choice between alternative actions, which are associated with particular probabilities (prospects) or gambles (<http://prospect-theory.behaviouralfinance.net/>).

**Risk Theory:** Risk theory is a theory of decision-making under probabilistic uncertainty. From a mathematical point of view it is a branch of probability theory, while its applications cover all aspects of life (<http://risktheory.net>).

**Risk:** (1) A function of the uncertainty of an outcome and its impact. (2) A measure of uncertainty combined with the potential outcome (Riesch, 2013). An uncertainty that can be expressed as a probability or frequency based on empirical data.

**Statistical Literacy:** (1) a broad cluster of behaviours, not only of factual knowledge and certain formal and informal skills, but also of desired beliefs, habits of mind, or attitudes, as well as a general awareness and a critical perspective. (2) the ability to understand and critically evaluate statistical results that permeate daily life (Gal, 2002).

**Statistical Literacy framework:** Consists of three levels (1) a basic understanding of probabilistic and statistical terminology (2) an understanding of statistical language and concepts when they are embedded in the context of wider social discussions and (3) a questioning attitude one can assume when applying concepts to contradict claims made without proper statistical foundation (Gal, 2002).

**Theoretical probability:** Is the measure of the chance of that event occurring in any trial of the experiment (using arguments of symmetry). Is the measure of the chance of that event occurring in any trial of the experiment (using arguments of symmetry).

**Quantitative Literacy:** Quantitative literacy refers to the knowledge and skills required to apply arithmetic operators to numbers embedded in printed materials (Canada Council on Learning, [www.ccl-cca.ca/ccl/topic/literacy/whatisliteracy.html](http://www.ccl-cca.ca/ccl/topic/literacy/whatisliteracy.html))

## APPENDIX B: Lesson Materials and Evaluations

**Risk Literacy Lesson 1: Exploring Context using IDEAS outline**  
Based on context analysis, Facione (2011), and Relational Analysis, Colorado State University (2016)

Use the outline below to analyze and summarize the case assigned:

| CATEGORY   |                               | QUESTIONS TO ASK:  | RESPONSE (List in point form) |
|--|-------------------------------|--|-------------------------------|
| I = Identify the problem and set priorities              | Assumptions & Personal Biases | Identify & list the underlying assumptions and biases (position taken, rules, process, values, or operating system)  |                               |
|  | Challenges                    | Identify what are the problem(s) and key issues?   |                               |
|  | Environment (current)         | Describe the current (relevant) physical, technical, socio-political environment.  |                               |
|  | External Factors              | What is the Geographical-location/proximity; size; technology; time; resources   |                               |
| D = Deepen understanding and gather relevant information | Strengths                     | Identify physical, technical or socio-political items or features that are advantageous  |                               |
|  | Threats                       | List potential hazards or risks-both minor to major? Others not evident?   |                               |
|  | Weaknesses                    | List deficiencies, constraints, or obstacles that can be encountered   |                               |
| E = Enumerate options and anticipate consequences        | Data & Numbers Used           | What is the form of the data? Identify type of math used. What are numbers being used to demonstrate? How is it being used? Can you verify the author's result yourself?         |                               |
|  | Opportunities (based on data) | Identify what actions can be or already have been taken. What resources are required, readily available, or currently in use? Do the actions require the formation of alliances? |                               |
|  | Resources                     | Identify financial, material, human, or technical resources that can be used   |                               |

|                              |  |  |                               |
|------------------------------|--|--|-------------------------------|
| A = Analysis and assessment  | Strength of relationship                 | Refers to the degree to which two or more concepts are related. These relationships are easiest to analyze, compare, and graph when all relationships between concepts are considered to be equal.             | RESPONSE (List in point form) |
|                              | Sign of Relationship (positive/negative) | Refers to whether or not the concepts are positively or negatively related to find out whether or not the words/concepts under observation or in question were used adversely or in favor of specific outcomes |                               |
|                              | Direction of Relationship                | Reciprocal – equal agreement of actions and rights between two parties;<br>Unilateral – actions and rights done or undertaken by one party or one person;<br>Nonexistent – no relationship exists              |                               |
|                              | Risk Perception Factors                  | Identify Risk Perception factors, Assumptions (social and cultural) and biases the influence behaviour and decision making   |                               |
| S = Scrutinize and summarize | Review & Map                             | Review the above to identify steps, connection, actions and impact   |                               |
|                              |  | Identify patterns of behaviour with actions taken  |                               |
|                              |  | Summarize or group related information together  |                               |
|                              |  | Critique information/actions. Describe how did risk perception and bias influence action/thinking  |                               |
|                              |  | Examine resulting outcomes. What was the impact?   |                               |
|                              |  | Examine alignment of communication with action. How does this impact relationships?  |                               |
|                              |  |  |                               |

## Risk Literacy - Lesson 1

### Article – Entrepreneurs financial knowledge, Toronto Star

2/4/2015

Many Canadian entrepreneurs lacking in basic financial knowledge

#### Business

#### **Many Canadian entrepreneurs lacking in basic financial knowledge**

More than one-third of small business owners failed a financial literacy quiz by Intuit Canada

**By:** Lisa Wright Business Reporter, Published on Mon Jan 26 2015

Small business owners in Canada are sorely lacking in basic financial knowledge that would help them to better manage their companies, a new Intuit Canada survey reveals.

While 93 per cent of entrepreneurs surveyed believe they possess an average or even advanced understanding of financial management principles, 39 per cent failed a 10-question financial literacy quiz, and 57 per cent achieved a score of 50 per cent or less, the e-finance software firm found.

"There are a lot of small businesses struggling to be profitable and competitive, so it's not good," said Rob King, Intuit's director of small business.

The quiz tested small business owners on their knowledge of financial management principles, with each a multiple-choice of four potential answers with one correct answer. Questions ranged from identifying a basic accounting principle to picking what does not affect a business' cash position.

He was surprised by the fact that only 26 per cent of entrepreneurs understood the role of a balance sheet, and that's down just two per cent from the first time Intuit commissioned the survey in 2012.

"They're pretty basic questions (for people in business). You learn about balance sheets even in high school," King said.

Other results showed that just 27 per cent could correctly identify that permanent assets are needed to meet a firm's long-term needs, down one per cent from 2012.

The survey results revealed seven per cent received a score of 9 or 10 and just two per cent answered all 10 questions correctly. Atlantic Canada respondents fared the best, with 18 per cent getting 9 out of 10 answers right and Quebec ranked lowest, with only four per cent achieving that score.

On the plus side, 47 per cent of entrepreneurs said they believe that basic financial training would help their businesses be more profitable, up 15 per cent from 2012. The survey is free online at [knowyourworth.ca](http://knowyourworth.ca)

From last November 20- 28, Vision Critical surveyed 683 Canadian small business owners. The margin of error for the total sample is within 3.7 per cent, nineteen times out of twenty.

### Lesson 3 – Risk Literacy

#### Exploring the relationships between language and math

**Exercise 1:** According to the Boston Globe (Dec. 27, 1980), an unpublished Department of Energy study states that since its beginning nuclear power has benefited from federal aid in five major areas: \$23.6 billion for research and development, \$237.4 million to promote foreign reactor sales, \$2.5 billion for uranium market promotion, \$7.1 billion in fuel enrichment pricing and aid, and \$6.5 billion for management of wastes, mining spoils cleanup, and unpaid decommissioning costs. (adopted from Frankenstein, 2014.  
<http://radicalteacher.library.pitt.edu>)

Q1. Find the total federal subsidy to the nuclear power industry.

Q2. (a) Write a brief statement of your opinion about nuclear power.

(b) Work in a group with three or four others who have similar opinions and list the kinds of numerical data that would support your opinion.

(c) Find at least one of the facts that you feel would support your opinion and describe how you would find the others.

**Exercise 2:** Consider the problem and draw the resulting figure using instructions (a) and (b). Compare and discuss your results. (adopted from Martin, 1994)

(a) Triangle ABC has a right angle at vertex B. I is a point on side AB between the endpoints. How does the sum of the measures of line segments AB + BC compare to the sum of the measures of AI + IC? Draw the diagram.

(b) Point A is my house and Point C is my school. Inside triangle ABC is the wooded area. Normally, I walk from my house (A) up the block to the corner (b), turn right and walk to the school (C). Sometimes, as I am walking up the block, I cut through the woods (from point I). I know that when I cut through the woods, the walk is shorter. I also know that the sooner [closer to A] that I cut through the woods, the shorter I have to walk. Draw the diagram.

## Lesson 5 – Risk Literacy

### Numeracy and Mathematical thinking

Exercise 1 - Mathematical Statements (adopted from Devlin, 2012)

Rewrite the following ambiguous newspaper headlines in a way that avoids a second meaning.

- a) Sisters reunited after ten years in checkout line at Safeway.
- b) Prostitutes appeal to the Pope.
- c) Large holes appear in High Street. City authorities are looking into it.
- d) Mayor says bus passengers should be belted.

Exercise 2 – Evaluate the following statements using the following operators below. Any calculations in brackets are done first:

$*$ (multiplication);  $/$  (division);  $+$  (addition);  $-$  (subtraction);  $^$  (exponents)

- a)  $(13.50 + 8.99 + 17.69) / 8 - 5 =$
- b)  $789/9 * 25 - 24 =$
- c)  $(328 + 14.5)/15 =$
- d)  $56 + 87 + 94/25 =$

Exercise 3 - Restate (simplify) the following symbolic statements as much as you can, leaving your answer in the standard symbolic form. Use the following symbols to evaluate the statements below.  $(^)$  = And;  $(>)$  = Greater Than;  $(<)$  = Less Than;  $(\pi) = 3.14$   $(\geq)$  = Greater than and equal  $(\leq)$  = Less than and equal

Example 1:  $(\pi > 3) \wedge (\pi < 3.2)$

The statement reads:  $\pi$  is greater than 3 AND  $\pi$  is less than 3.2

Example 2:  $(a < x) \wedge (x \leq b)$

Statement reads:  $a$  is less than  $x$  AND  $x$  is less than and equal to  $b$

Answer (Simplified):  $a < x \leq b$

- a)  $(\pi > 0) \wedge (\pi < 10)$
- b)  $(p \geq 7) \wedge (p < 12)$
- c)  $(x > 5) \wedge (x < 7)$
- d)  $(x < 4) \wedge (x < 6)$



### RL Lesson 5 - Application of Percent (adopted from Frankenstein, 2014)

Case: According to "Eating Better for Less" by Lucille Sandwith (Food Monitor, Oct. 1980) fifty out of the 32,000 U.S. food manufacturing firms make 75 percent of the net profits. Of these top fifty corporations, thirty-one bought 63 percent of the national media advertising, or roughly \$5 billion in 1977. Of the top twenty-five advertisers from all industries, eighteen were food companies.

Q1. What percent of the U.S. food manufacturing firms make 75 percent of the net profits?

Q2. Based on the information given, create and solve a math problem whose solution involves using percents.

### Converting Percentages to Probability Statements (adopted from Sprinthall, 2003)

To convert percentages to probability statements we divided the percentages by 100 and drop the percentage sign (percentage signs cancel out). The formula is

$$P = \frac{\% \text{ of cases}}{100\%}$$

Therefore, if the frequency of occurrence is 90%, then

$$P = \frac{90}{100} = .90$$

**Example:** Suppose we wish to determine the probability of selecting a diamond from a normal deck of playing cards, that is, 52 cards divided into 4 suits – diamonds, hearts, clubs and spades. The probability of the specific event, a diamond, is therefore, one out of four (the total number of suits in the deck is four)

$$P = \frac{1(\text{number of suits chosen})}{4(\text{total \# of suits in deck})} = .25$$

Therefore, the probability of selecting a diamond from the deck is 0.25.

## RL Lesson 5

## Notes: Three Faces of Probability

(Gigerenzer, 2014)

Probability is not unique, it has three faces: frequency, physical design, and degrees of belief

|                   |   |
|-------------------|---|
| Frequency         | Probability is about counting. Counting the number of days with rainfall or the number of hits a baseball player makes and dividing these by the total number of days or strikes results in probabilities that are relative frequencies. Use frequencies instead of single-event probabilities when calculating and communicating risk.   |
| Physical Design   | Probability is about constructing. For example, if a die is constructed to be perfectly symmetrical, then the probability of rolling a six is one in six. You don't have to count. Probabilities by design are called <i>propensities</i> . These risks are known because people crafted, not counted, them. E.g. gambling & card games   |
| Degrees of Belief | A degree of belief can be based on anything from experience to personal impression. But how to quantify these intuitions? The risk of a major accident in a nuclear power plant can be estimated by counting earlier accidents, or by the physical design of the plant, or by expert's degrees of belief, or some mixture of these. It is always important to ask how the risk of a nuclear meltdown, or any other risk, was actually calculated. |



# Lesson 6 – Risk Communication & Risk literacy

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**Lesson 6 – Risk Literacy**  
**RISK MISCOMMUNICATION CHECK LIST**

| TYPE                                     | PRESENT(y/n) | DESCRIPTION |
|--|--------------|-------------|
| Ignorance of risk                        |              |             |
| Innumeracy                               |              |             |
| Overestimating probability               |              |             |
| Risk Perception Gap                      |              |             |
| Ignorance of risk                        |              |             |
| Different interpretations of probability |              |             |
| Illusions of Certainty                   |              |             |
| Improper risk measurement                |              |             |
| Educational blind spot                   |              |             |
| Experts                                  |              |             |
| Zero-Risk Illusion                       |              |             |

**Lesson 6 – Risk Literacy**  
**FORMS OF RISK MISCOMMUNICATION**

1. Ignorance of risk
2. Innumeracy – inability to comfortably deal with numbers
3. Different interpretations of probability can produce drastically different estimates of risk
4. Illusions of Certainty
5. Improper risk measurement i.e. methods that wrongly assume known risks in a world of uncertainty. Because these calculations generate precise numbers for an uncertain risk, they produce an illusory certainty.
6. Educational blind spot – subject not taught/missing from education system
7. Experts are part of the problem – not properly educated/make mistakes
8. Less IS MORE – complex problems do not always require complex solutions
9. Zero-Risk Illusion – quest for absolute certainty
10. Risk IS NOT uncertainty
11. OVERESTIMATING THE PROBABILITY – over estimating the probability of highly improbable events
12. Risk Perception Gap – Tendency to emphasize the benefits and play down the risks in our minds. The smaller the benefit the greater the risk appears.

## LESSON 6: Risk Communication

Listed below are examples of 3 common forms of risk communication that create confusion and miscommunication: (A) Single-Event Probabilities (B) Relative Risks and (C) Conditional Probabilities (Gigerenzer, 2002).

|  | Example(s)   | Problems  |
|--|--|---|
| (A) Single-Event Probability               | i ...there is a 30 percent chance that it will rain tomorrow'  | (a) Does not state Reference Class & (b) statement is ambiguous   |
|  |  | If it is a UNIQUE event there are <u>no comparable events known</u> , estimate is likely to be a wild guess & can never be proven wrong |
| How this information can be misinterpreted | ii i.e. 'Some people think that it will rain 30 percent of the time', OR 'It will rain in 30 percent of the area', OR 'It will rain on 30 percent of the days that are like tomorrow'.   | Can lead to miscommunication because people will fill in different reference classes.   |
| What to do?                                |  | Ask what the 30 percent refers to?  |
| (B) Relative Risk                          | i People with high cholesterol can rapidly reduce their risk of death by 22 percent by taking (pravastatin sodium) this drug.  | What does 22% mean?   |
|  |  | Results presented as a relative risk look more impressive than results reported as an absolute risk                                     |
|  |  | Relative risk are larger numbers than absolute risk and therefore suggest higher benefits   |
| What to do?                                | Out of 111 people who take this tablet for 5 years, 1 had the benefit, whereas 110 did not.  | Look for or ask for these values as an Absolute risk  |
|  |  | Present benefits in terms of the number need to treat to save one (1) life.   |
| (C) Conditional Probabilities              | i (a)'If a woman has breast cancer, the probability that she will test positive on a screening mammogram is 90 percent'. Will be confused with (b) 'if a woman tests positive on a screening mammogram, the probability that she has breast cancer is 90 percent'. | An event A occurs given event B' is confused with the conditional probability that 'an event B occurs given event A'.                   |
|  |  | Others mistake the probability of A given B, with the probability of A and B.   |
| What to do?                                |  | Replace conditional probabilities with natural frequencies  |
|  |  | Illustration/diagram of natural frequencies   |

# Lesson 7– Representations and Evaluating Risk

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## Decoding our Perceptions of Risk using Risk Perception Factors

based on 'How Risky Is It Really?', D. Ropeik (2010)

Designed by Dianne J.R. Kenton

Risks have personality traits that help us instinctively judge their character (Ropeik, 2010).

**Definition of Risk Perception Gap:** Whenever the choice involves BOTH risk and benefit, the greater the benefit, the more we play down risk in our minds. The smaller the benefit, the greater the risk is likely to seem. This is called a *risk perception gap*.

**Risk Perception Factors:** How we perceive risk is not just a matter of the statistical or scientific facts, it's a matter of perspective, and that perspective is powerfully informed by how we compare the risk versus the benefits. These factors, individually and in combination, can make us feel more or less afraid. If there is little perceived benefit, the associated risk will look bigger (Ropeik, 2010). These factors can help one to understand and uncover what governs our decision making.

As part of the context analysis exercise use the Table of Risk Perceptions factors below to (a) identify and describe the risk perception and (b) identify the Risk Perception Gap

Table of Risk Perception Factors

| PERCEPTION FACTOR              | WHAT DOES THAT LOOK/SOUND LIKE?  | HOW DO WE BEHAVE?   |
|--------------------------------|--|---|
| Control                        | Humans have innate drive to control their environment. E.g. Driving - affords some degree of control despite statistics, it FEELS safer  | More Control = Less Afraid<br>Less Control = More Afraid  |
| Benefit versus Risk            | We take fewer precautions when we feel that the perceived benefit out-weighs the risk. We take fewer precautions & your actual risk is either the same or it increases   | Greater Benefit = Less worry about associated Risk<br>Smaller Benefit = Larger the Danger   |
| Choice                         | We perceive the risk to be the same or less when we choose it. Influenced by Optimism Bias (i.e. It won't happen to me).   | When we <i>choose</i> the risk = less afraid.<br>When the same risk is <i>imposed</i> = feels more threatening  |
| Natural versus Human Made Risk | We just don't worry as much about risks from natural sources as risks that are human-made. Can cause a perception gap (lack of understanding/regulation) puts us at greater risk   | Natural risk = less worry<br>Man-made risk = greater worry  |
| Pain and Suffering             | Events/situations that we perceive carry greater pain & suffering, we fear more. The flip-side is that it leaves us less afraid of some really major threats that harm us in relatively less awful ways.   | Influenza = not frightening<br>Cancer = frightening   |
| Uncertainty                    | The more uncertain we are, the more afraid we are likely to be. Fear arises when we don't have the information we need to protect ourselves.<br><b>3 Types of Uncertainty:</b> (1) I Can't Detect it –using senses; (2) I Don't Understand it? (3) Nobody knows. | Brain shifts from rational response to affective (instinctive/fight or flight) response.<br>N.B. - The less we understand the scientific explanations of risk, the less our cognitive, fact-based, analytical brain system can help, and the more we rely on instinctive Risk Perception Factors to help keep ourselves safe. |

| PERCEPTION FACTOR            | WHAT DOES THAT LOOK/SOUND LIKE?   | HOW DO WE BEHAVE?   |
|------------------------------|---|---|
| Uncertainty & Precaution     | What to do when we're not sure? How to deal with the nature of uncertainty. (See <i>Precautionary Principle</i> )   | Uncertainty is inherent in progress. It is also inherently a factor that feeds our fears. Fear is a result of uncertainty and loss of control.        |
| Catastrophic v.s. Chronic    | Our risk response depends on the affective nature of the threat, not just the number of victims. These events have 3 or more affective qualities:<br>a) Size and scale – affecting hundreds of thousands<br>b) Time frame – Sudden and without warning<br>c) Consequences – disastrous, calamitous, horrific, large loss of life<br>d) Location – taking place in a single location | Catastrophic events = greatest perceived threat<br>Catastrophic events happen with less frequency and impact fewer people.                            |
| Chronic                      | When loss is spread out over space and time. Chronic events can have the same number or greater fatalities but spread out over a longer time frame and much larger area – appearing to be less threatening. E.g. Heart Disease kills more Americans per year than deaths due to terrorist attack, cancer or plane crashes.  | Perceived as less threatening. As a result we are less prepared and protected – putting ourselves at greater risk.                                    |
| Can it happen to me?         | Any risk feels bigger if you think it could happen to you. Fear spreads rapidly when you believe the threat can happen to you.  | Numbers and probabilities are only part of how we gauge the threats we face. The risk may be one in a million, but do you think you could be the one? |
| Is the risk New or Familiar? | New or Unfamiliar risks, appear as more threatening due to uncertainty and the fact that unfamiliar risks may be imposed.   | New Risk = Higher perceived Risk<br>Familiar Risk = Lower perceived Risk  |
| Risks to children            | Any risk to children evokes more fear than the same risk if it only affects adults. Our instinct is to protect the young to ensure survival. We are instinctively sensitive about risk to kids – so much so that we do not perceive the same threat to adults.  | Risk to child = Higher perceived Risk<br>Same risk to adult = Lower perceived Risk  |
| Personification              | When risk is personified, when the victim or potential victim is represented as a real person, the risk evokes more concern. The same risk represented merely as an idea, or terms of impersonal statistics, or on a population-wide or global basis, evokes less concern.  | Risk in terms of people = Greater concern<br>Risk in terms of statistics = Less concern   |
| Fairness                     | Risks that impact the poor or weak or the disadvantaged, or risks where the danger is faced by one group while another group gets the benefits, tend to seem worse because they aren't fair   | Fairness = less perceived risk<br>Unfairness = greater perceived risk   |



# Lesson 8 – Evaluating Risk & Risk Perception

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Lesson 8 - RELATIVE RISK  
Part 2 Restating the case (Gigerenzer, 2014)

The same statement/problem from Part 1 is now expressed as a natural frequency. Can you evaluate this statement?

**CASE** *Think of 100 women. One (1) has breast cancer, and she will probably test positive. Of the 99 who do not have breast cancer, 9 will also test positive. Thus, a total of 10 women will test positive. How many of those who test positive actually have breast cancer?*

**QUESTION**

1. What is your reaction to this question this time? Were you still confused or can you readily arrive at an answer?
2. Did you have difficulty arriving at an answer? Were you still confused or in a fog?
3. Was this method helpful to you? Why or why not?

**ANSWER & DISCUSSION:**

1. One (1) woman out of 10 who tested positive will actually have breast cancer.
2. This is a chance of 10%, NOT 90%.
3. If the relevant information is expressed as a natural frequency one can see, in this case, that the majority of women who are screened do not really have breast cancer.

**Lesson 10: Summative Evaluation Rubric A- Constructing knowledge**  
**(based on Bloom's Revised Taxonomy)**

I) Objective: Construct and evaluate

Knowledge domain: Meta-cognition

Cognitive process: (a) Evaluate – analyze, rank, assess, conclude, action  
 (b) Construct – plan, compose, combine, actualize, demonstrate, integrate

II) Evaluation:

| Cognitive Process | L1 | L2 | L3 | L4 | L5 | L6 |
|-------------------|----|----|----|----|----|----|
| Analyze           |    |    |    |    |    |    |
| Rank              |    |    |    |    |    |    |
| Assess            |    |    |    |    |    |    |
| Action            |    |    |    |    |    |    |
| Conclude          |    |    |    |    |    |    |
|                   |    |    |    |    |    |    |
| Plan              |    |    |    |    |    |    |
| Combine           |    |    |    |    |    |    |
| Compose           |    |    |    |    |    |    |
| Actualize         |    |    |    |    |    |    |
| Demonstrate       |    |    |    |    |    |    |
| Integrate         |    |    |    |    |    |    |
|                   |    |    |    |    |    |    |
|                   |    |    |    |    |    |    |

L1 = Remember - minimal level (basic)

L2 = Understands

L3 = Apply

L4 = Analyze

L5 = Evaluate

L6 = Create - highest level

**Risk Literacy Lesson 10:**  
**Summative Evaluation Rubric B- Critical Thinking Rubric**  
*(adapted from Northeastern Illinois University Critical Thinking Rubric)*

| Macro Criteria & Quality   | No/Limited Proficiency = (Grade D & E)   | Some Proficiency = (Grade C)  | Proficiency = (Grade B)  | High Proficiency = (Grade A)   | RATING (A,B,C,D,E) |
|--|--|---|--|--|--------------------|
| 1. Identifies & Explains Issues                                  | Fails to identify, summarize, or explain the main problem or questions. Represents the issues inaccurately or inappropriately.   | Identifies main issues but does not summarize or explain them clearly or sufficiently   | Successfully identifies and summarizes the main issues, but does not explain why/how they are problems or create questions                   | Clearly identifies and summarizes main issues and successfully explains why/how they are problems or questions; and identifies embedded or implicit issues, addressing their relationship to each other.                 |                    |
| 2. Distinguishes Types of Claims                                 | Fails to label correctly any of the factual, conceptual and value dimensions of the problems and proposed solutions.   | Successfully identifies some, but not all of the factual, conceptual, and value aspects of the questions and answers.   | Successfully separates and labels all the factual, conceptual, and value claims  | Clearly and accurately labels not only all the factual, conceptual, and value, but also those implicit in the assumptions and the implications of positions and arguments.   |                    |
| 3. Recognizes Stakeholders and Contexts                          | Fails accurately to identify and explain any empirical or theoretical contexts for the issues. Presents problems as having no connections to other conditions or contexts        | Shows some general understanding of the influences of empirical and theoretical contexts on stakeholders, but does not identify many specific ones relevant to situation at hand. | Correctly identifies all the empirical and most of theoretical contexts relevant to all the main stakeholders in the situation.              | Not only correctly identifies all the empirical and theoretical contexts relevant to all the main stakeholders, but also finds minor stakeholders and context and shows the tension or conflicts of interest among them. |                    |
| 4. Considers Methodology   | Fails to explain how/why/which specific methods of research are relevant to the kind of issue at hand.   | Identifies some but not all methods required for dealing with the issue; does not explain why they are relevant or effective.   | Successfully explains how/why/which methods are most relevant to the problem.  | In addition to explaining how/why/which methods are typically used, also describes embedded methods and possible alternative methods of working on the problem.  |                    |
| 5. Frames Personal Responses and Acknowledges Other Perspectives | Fails to formulate and clearly express own point of view, (or) fails to anticipate objections to his/her point of view, (or) fails to consider other perspectives and positions. | Formulates a vague and indecisive point of view, or anticipates minor but not major objections to his/her point of view, or considers weak but not strong alternative positions.  | Formulates a clear and precise personal point of view concerning the issue, and seriously discusses its weaknesses as well as its strengths. | Not only formulates a clear and precise personal point of view, but acknowledges objections and rival positions and provides convincing replies to these.  |                    |

| Macro Criteria & Quality  | No/Limited Proficiency = (Grade D & E)  | Some Proficiency = (Grade C)   | Proficiency = (Grade B)  | High Proficiency = (Grade A)  | RATING (A,B,C,D,E) |
|---------------------------|---|--|--|---|--------------------|
| 1. Reconstructs Arguments | Fails to identify the major components of the main arguments at stake and to show their logical relations.                                  | Identifies a few of the premises but confuses the conclusion of the main argument in support of the position under consideration (his or her own, or that of others) | Correctly analyzes the arguments and theories; restates its component propositions and reconstructs their relationships correctly. | Not only correctly reconstructs the main argument but does the same for subsidiary arguments and theories, and correctly identifies the kind or status of each of them. |                    |
| 2. Interprets Content     | Fails to identify and choose between the possible meanings of the key terms and propositions included in the arguments and theories in use. | Clarifies the meaning of a few but far from all of the key terms and propositions involved.  | Convincingly explains the meaning of all the key terms and main propositions involved in the arguments and theories involved.      | Offers fine-grained and original interpretations of a crucial term or proposition involved in the issue.  |                    |
| 3. Evaluates Assumptions  | Fails to identify and evaluate any of the important assumptions behind the claims and recommendations made.                                 | Identifies some of the most important assumptions, but does not evaluate them for plausibility or clarity.   | Identifies and evaluates all the important assumptions, but not the ones deeper in the background – the more abstract ones.        | Not only identifies and evaluates all the important assumptions, but also some of the more hidden, more abstract ones.  |                    |
| 4. Evaluates Evidence     | Fails to identify data and information that counts as evidence for truth-claims and fails to evaluate its credibility.                      | Successfully identifies data and information that counts as evidence but fails to thoroughly evaluate its credibility.   | Identified all important evidence and rigorously evaluates it.   | Not only identifies and rigorously evaluates all important evidence offered, but also provides new data or information for consideration.                               |                    |
| 5. Evaluates Inferences   | Fails to identify and explain mistakes in the reasoning of others and fails to avoid them in his or her own reasoning.                      | Successfully identifies and avoids some common mistakes of reasoning but misses less common ones, and does not explain why or how they are mistakes.                 | Identifies and avoids all mistakes of reasoning and explains some of them.   | Not only identifies and avoids all mistakes of reasoning but gives clear explanations of why they are mistakes.   |                    |

## Resource Links

<http://www.almanac.com/content/predicting-tornadoes-radar-screen>

### BMI Calculators

<http://www.smartbmiccalculator.com/>

<http://www.diabetes.ca/diabetes-and-you/healthy-living-resources/weight-management/body-mass-index-bmi-calculator>

[http://www.nhlbi.nih.gov/health/educational/lose\\_wt/BMI/bmicalc.htm](http://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmicalc.htm)

<http://canadatornado.com/ontario/history/>

Canadian Diabetes Association. Body Mass Index and risk of diabetes.

<http://www.diabetes.ca/diabetes-and-you/healthy-living-resources/weight-management/body-mass-index-bmi-calculator>

Canadian Cancer Society. Breast cancer. <http://www.cancer.ca/en/cancer-information/cancer-type/breast/breast-cancer/?region=on>

Heart and Stroke Foundation.

[http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3484041/k.D80A/Heart\\_disease\\_Women\\_and\\_heart\\_disease\\_and\\_stroke.htm](http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3484041/k.D80A/Heart_disease_Women_and_heart_disease_and_stroke.htm)

National Weather Service – Storm Prediction Center <http://www.spc.noaa.gov/>

<http://news.nationalgeographic.com/news/2014/04/140428-tornado-prediction-warn-on-forecast-science/>

<http://newsfeed.time.com/2012/03/07/tornado-season-how-do-meteorologists-predict-twisters/>

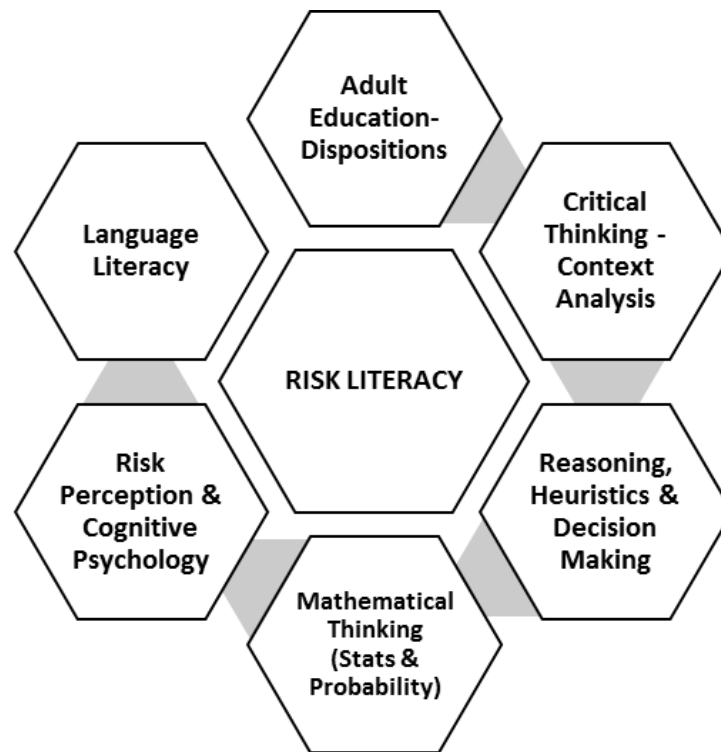
<http://www.scientificamerican.com/article/improving-tornado-prediction/>

<http://www.theverge.com/2013/5/23/4358728/the-science-of-tornado-prediction-moore-oklahoma>

### **APPENDIX C: Reviewer Questionnaire**

*Please answer the following questions below on the enclosed printed copy or in this document. Please return both to me when they are completed. Thank you for your time and comments.*

1. Are the 'Objectives' for this lesson clear and well stated?
2. Do the activities adequately demonstrate and reinforce the concepts discussed in the lesson?
3. Is the assessment (*what did you learn?*) type and level appropriate?
4. Are there sufficient resources and adequate background information provided for the lesson?
5. Were lesson instructions clear and understandable?
6. Did the lesson have a logical progression or flow?
7. Other comments:



*Figure 1.* Proposed Risk Literacy Model.